Columbia College
School of Mines

Circular of information 1883-4

COLUMBIA COLLEGE.

SCHOOL OF MINES.

CIRCULAR

OF

INFORMATION.

1883-1884.

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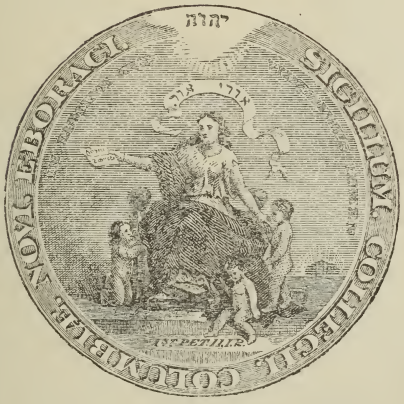
FOR THE YEAR

1883—1884.



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CONTENTS.

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GENERAL STATEMENT.

THE system of instruction includes six parallel courses of study, viz.:

I. Mining Engineering.

II. Civil Engineering.

III. Metallurgy.

IV. Geology and Palæontology.

V. Analytical and Applied Chemistry.

VI. Architecture.

During the first year, the instruction given to all the students of the First Class is the same; at the beginning of the second year, each student must elect which of the six courses he intends to pursue, and must thenceforth abide by his election unless permitted by the Faculty to make a change. No student is permitted to pursue a special or partial course.

The plan of instruction includes lectures and recitations in the several departments of study; practice in the chemical, mineralogical, blowpipe, and metallurgical laboratories; field surveying; practice in operative mining; projects, estimates, and drawings for the establishment of mines, and for the construction of metallurgical, chemical, and other works; reports on mines, industrial establishments, and field geology.

The course of instruction occupies four years.

There is an advanced course for graduates of the school.

The method of instruction is such that every pupil may acquire a thorough theoretical knowledge of each branch, of which he is required to give evidence, at the close of the session, by written and oral examinations. At the commencement of the following year he is required to show, from reports of works visited, that he understands not only

the theoretical principles of the subjects treated, but also their practical application—a point that is insisted on with great rigor.

ADMISSION.

Candidates for admission to the First Class, at its formation, must be of the age of seventeen years, complete; and, for admission to advanced standing, there will be required a corresponding increase of age.

Candidates for the First Class must pass a satisfactory examination in Arithmetic, including the metric system of weights and measures; in Algebra, on the first ten chapters of Peck's Manual of Algebra; in Geometry, on the first six books of Davies' Legendre; in Physics, on the equivalent of Ganot's smaller Treatise (Peck's Ganot's Natural Philosophy); in French, on the general principles of French Grammar, including an ability to read Montmahou's Cours d'Histoire Naturelle, or its equivalent; in German, on the general principles of the German Grammar, including an ability to read Hans Andersen's Mährchen, or its equivalent; in English Grammar, on the equivalent of Quackenbos's English Grammar; in Composition and Rhetoric, on the equivalent of Quackenbos's Course of Composition and Rhetoric; in History, on the equivalent of Thompson's History of England and Doyle's History of the United States as contained in Freeman's Historical Course for Schools; in Physical Geography, on the equivalent of Guyot's Physical Geography; and in Free Hand Drawing, including the ability to sketch, both in outline and with proper shading, ordinary objects, such as a tree, a house, a simple piece of machinery, a piece of flat ornament from a copy, a group of geometrical solids, etc.

Candidates for advanced standing must pass a satisfactory examination upon the studies named above, and also upon those pursued by the class which they propose to enter.

Candidates for admission after the opening of a term will be required to pass satisfactory examinations on the part

of the course already gone over by the class for which they are applicants.

No candidates are admitted later in the course than the beginning of the third year.

Graduates and students of colleges and schools of science, who shall have completed so much of the course as shall be equivalent to the requirements for admission, may be admitted at the beginning of the second year, or earlier, without examination, on presenting diplomas or certificates of good standing and honorable dismissal satisfactory to the examining officers.

The regular examinations for admission are held annually, beginning on the Friday before commencement, and on the Tuesday preceding the first Monday in October. Candidates will, however, be examined during the session, but not in vacation.

The annual tutition fee is two hundred dollars, payable one-half on the first day of each session.

FREE STUDENTS.

Whenever it appears to the satisfaction of the President and the Treasurer of the college that a student, who is of good moral character and industrious habits, desires to pursue the studies of the school, but is unable to pay the usual fees for tuition, he may be admitted without charge.

Each candidate for free tuition must fulfil the following conditions:

1. He must present a certificate from some person of good repute, stating that the writer is acquainted with the circumstances of the applicant (his parent or guardian, if he has such) and knows him to be unable to bear the expense of his education if obliged to pay the tuition fee; also, that he (the writer) is not himself a relative of the applicant.

A proper blank will be furnished on application to the Registrar.

2. He must exhibit a proficiency in every subject of examination expressed by the number 6 of a scale in which 10 is the maximum.

3. He must maintain subsequent to his admission, a standing in scholarship, also in every branch, expressed by the number 7 of a similar scale, failing which he will forfeit his privilege.

APPARATUS SUPPLIES.

I. Students may purchase apparatus of any of the dealers in the city.

II. To save inconvenience and expense to the students, and to secure a proper selection, the school undertakes, at considerable trouble and expense, to lend apparatus on the following conditions:

1. Each student must make a deposit with the Registrar, which deposit will be credited to him on the ledger. This deposit will be $25 for students of the Second Class, $40 for students of the Third Class, and $50 for students of the Fourth Class.

2. Each student will be entitled, on presenting his receipt at the supply room, to draw the regular set of apparatus for qualitative or quantitative analysis, or for assaying, according to his deposit, and from time to time to obtain ordinary articles which he may need, and these will be charged to him. At the end of the session he will be credited with those articles which he returns in good order, and the value of those which he has injured or broken will be deducted from his deposit.

III. The supply room will be open for issuing supplies every day at convenient hours.

IV. No charge is made for ordinary chemicals.

EXCURSIONS.

During the session, the students may visit the different machine shops and metallurgical establishments of the city and its environs.

During the vacation, each student is expected to visit mines, metallurgical and chemical establishments, and to hand in, on his return, a memoir on some subject assigned him. He is also required to bring collections illustrating his memoir, which collections are placed in the museum, reserved as a medium of exchange, or made use of in the laboratories.

During the vacation following the close of the second year, students of engineering may join a volunteer class in practical mechanical engineering under the supervision of the Adjunct Professor of Mechanical Engineering.

During the vacation following the close of the third year, students of mining engineering visit a mine and engage in actual work or study under the superintendence of the Adjunct Professor in Surveying and Practical Mining.

During the vacation following the close of the third year, the students of civil engineering are required to attend a summer class in Geodesy for six weeks. The class is under the supervision of the Director of the Observatory and Instructor in Geodesy.

SCHOLASTIC YEAR.

The year is divided into two sessions: The first commences on the first Monday in October; the second, on the first or second Thursday of February. The lectures close on the Friday of the fourth week before commencement.

EXAMINATIONS.

There are two examinations every year, one commencing on the last Monday in January, and the other on the Monday of the third week preceding commencement. The lat-

ter is the final examination in each department of all the classes for the year. The former embraces such subjects only as have been completed during the first session.

In addition to the examinations above noted, examinations are held monthly in all the classes, and in every department, for the purpose of ascertaining the proficiency of the students in their respective studies.

COMMENCEMENT AND VACATION.

The annual commencement is held on the second Wednesday in June, on which occasion degrees are publicly conferred.

A vacation of all the classes extends from the day of commencement until the first Monday in October, on which latter day the regular course of study commences.

The exercises of the school are suspended on public holidays established by law, on such days in each year as may be recommended by the civil authority to be observed as days of fast or thanksgiving, and for two weeks from the third (or fourth) Monday in December.

NECESSARY EXPENSES.

Board, including room-rent, fire and light, and washing, may be had in the city for six and a half to nine dollars per week. Annual tuition fee $200. Text books about $15 for the first class, $30 for the second class, $50 for the third class, and $20 for the fourth class. Drawing materials $15 to $25 for each of the first and second classes, and $5 to $10 for each of the others. Laboratory apparatus $30 to $60 for each of three years. During the vacation at the close of the third year, travelling and board for summer class in Practical Mining (Mining Engineers only), and for summer class in Practical Geodesy (Civil Engineers only), $50 to $60. Graduation, including Diploma, $5.

The fees required of graduates of the school, attending the school, are as follows:

1. Full fee entitling the student to all the privileges of the school, per annum $150
2. For the use of the library and cabinets 25
3. For attendance on lecture-room and other special instruction, per annum for each hour per week of such instruction 25

   Or for any number of hours per week as above specified 150
4. For the use of the drawing academy 25
5. For the use of the laboratories, or either of them 50

Should the amount of fees payable by any student not exceed $100, the entire amount is payable at the beginning of the academic year, or at the matriculation of the student. Should the amount exceed $100, payment is required in two equal instalments, one at the beginning of each session of the academic year.

BY-LAWS.

FULFILLING CONDITIONS.

1. Conditioned students must fulfil all conditions within two months of the date of their admission.

ATTENDANCE.

2. Prompt attendance is required upon all the exercises of the school. Each instance of tardiness will be counted as half an absence.

3. Any student who shall have been absent from more than ten per cent. of the exercises in any subject, shall not be entitled to examination thereon.

4. Any student who, being present at the school, shall absent himself from any exercise, or shall leave the grounds during the hours at which his attendance is due, shall be liable to removal from the roll of his class.

5. Students are required to attend all the exercises and pass all the examinations of the class and course to which they belong, unless specially excused by vote of the Faculty.

6. Students who obtain on examination a mark of 8 or more in any subject, may be excused from attendance upon the exercises in that subject. This rule to apply to new students and also to those who repeat the studies of any year. Reports of such standing must be filed with the Dean of the Faculty, who alone is authorized to excuse students from attendance.

7. Any student who shall have passed a satisfactory examination in the School of Arts of Columbia College in any study forming a part of the regular course in the School of Mines, will not be required to pursue that study in the school.

EXAMINATIONS.

8. Examinations will be held each month, on all subjects taught in the school.

9. Examinations will be held at the end of the first term (semi-annual), or at the end of the year (annual), on all subjects taught in the school.

10. No student who absents himself from a regular examination is allowed to proceed with his class without a special vote of the Faculty.

11. Any student who shall fail to pass in any of his studies at the regular examination at the end of the academic year, may present himself for a second examination during the last week of the summer vacation. Failing to pass in this second examination, he can only go on with his class by special permission of the Faculty, and provided that he takes private instruction approved by the Faculty, and within two months from the beginning of the term, presenting to the Faculty a favorable report of his progress from his instructor. This will entitle him then to a third examination, failing in which his name shall be dropped from the roll of the class.

12. Examinations at times other than here designated are not held except by order of the Faculty.

13. Students deficient in any department are not allowed to go on with their classes without a special vote of the Faculty.

14. No student is entitled to a degree until he has passed satisfactory examinations in all the studies of the course in which he desires to graduate.

15. Any student who, at the close of the fourth year, may have failed to complete a course required for graduation, and desires to continue his studies in the school for a longer time, is permitted to do so; and, with the consent of the Faculty, may have an examination for a degree at the close of any subsequent term.

16. When a student fails to receive his degree with his class, and returns at some later period to present himself for examination for the same, he will be required to comply with all the requirements at the later date, and the same rule shall apply to students who have received one degree and make application for another.

STANDING.

17. Every officer keeps a record of the scholarship of each student.

18. The maximum mark is ten in each department, and six is required to pass a student.

19. Free students must maintain a standing of seven in every branch of study, failing which they will forfeit their privileges.

CHANGE OF COURSE.

20. No student shall be permitted to change his course till he has passed in every study of the course which he proposes to leave.

ANALYSES.

21. Analyses and Assays must be made on material supplied or authorized beforehand by the Instructor in charge of the laboratory, and the reports must be handed in on the completion of the work.

MEMOIRS.

22. Each student, at the commencement of his second, third, and fourth year, is required to present memoirs on such subjects as may be assigned to him by the Faculty.

23. Students of the Second, Third, and Fourth Classes who fail to hand in, on or before November 1st, the memoirs, drawings, and other Summer work required of them

under the rules, shall be dropped from the roll of their respective classes.

PROJECTS AND DISSERTATIONS.

24. Each student, before graduating, is required to execute projects or dissertations on subjects assigned to him by the Faculty. These projects or dissertations must be illustrated by drawings made to a scale.

25. All memoirs, projects, dissertations, and drawings executed in the drawing academy, may be retained by the School.

DEGREES.

26. Every student who has passed satisfactory examinations in all the studies of a course, and completed the required number of projects, dissertations, memoirs, analyses, assays, and drawings, is recommended to the Board of Trustees for the degree of Engineer of Mines, Civil Engineer, or Bachelor of Philosophy.

27. Graduates of the school, who fulfil the following conditions, are recommended to the Board of Trustees for the degree of Doctor of Philosophy :

(1.) Each candidate shall pursue, for the term of at least one academic year, a course of higher study, at the school and under the direction of the Faculty, in two or more branches of science, and shall pass an approved examination thereon.

(2.) He shall also present an acceptable thesis or dissertation embodying the results of special study, research, or observation, upon a subject previously approved and accepted by the Faculty.

SPEAKERS AT COMMENCEMENT.

28. A list of members of the graduating class, from whom the speakers at commencement may be chosen, will be

made by the Faculty and submitted to the class, who may select as speakers two of the number, subject to the approval of the Faculty.

LIBRARY.

29. The library is open to students from 9:30 A.M. to 4 P.M.

30. Books taken from the library must be returned within two weeks.

31. Students must give receipts for books taken, and are responsible for their return in good condition.

THE LABORATORIES AND DRAWING ACADEMY.

32. The analytical, assay, blowpipe, and mineralogical laboratories, and the drawing academy, are open on week days, except on Saturdays and during vacations, from 10 A.M. till 4 P.M.

33. No student will be allowed in a laboratory or the drawing academy at a time when his attendance there is not due. During hours assigned for practical work in each of the laboratories, in the drawing academy, and in practical surveying, the attendance of students will be required. A record of the daily attendance and of the progress of each student will be kept by the officer in charge.

ORDER.

34. Good order and gentlemanly deportment are required of all students, as a condition of attendance upon the exercises of the school.

35. Smoking is prohibited on the college grounds, as well as in the buildings.

SYNOPSIS OF STUDIES.

FIRST YEAR.

Common to all the Courses.

First Session.

Geometry—Plane, volumetric, and spherical; Conic Sections. Text books: Davies' Legendre and Peck's Conic Sections.

Algebra—Text book: Peck's Manual of Algebra.

Physics—Doctrines of heat, viz., expansion, conduction, radiation, thermometry, latent heat, tension of vapors, steam. Lectures, and "Atkinson's Ganot's Physics."

Chemistry—The non-metallic elements, through carbon. Lectures, and "Roscoe's Elementary Chemistry."

Qualitative Analysis—Lectures, and "Fresenius' Manual of Qualitative Analysis."

French—Text books: Jewett's Ollendorff's French Grammar, Montmahou's Cours d'Histoire Naturelle.

German—Text books: Wershoven's Technical Vocabulary, Schoedler's Buch der Natur, Parts I., II.

Drawing—Free hand and sketching: use of instruments; lettering, instrumental drawing; projections, intersections, and developments. Text book: Binn's Orthographic Projection.

Second Session.

Trigonometry and Mensuration, as contained in Davies' Legendre.

Physics—Specific heat, magnetism, electricity static and dynamic, thermo-electricity, induction, magneto-electricity, the electric telegraph. Lectures, and "Atkinson's Ganot's Physics."

Chemistry—To the metals. Lectures, and "Roscoe's Elementary Chemistry."

Qualitative Analysis—Lectures, and "Fresenius' Manual of Qualitative Analysis."
French—Text books: same as first session.
German—Text books: same as first session.
Drawing—Same as first session.

SUMMER VACATION.

MEMOIR.

I.—COURSE IN MINING ENGINEERING.

SECOND YEAR.

First Session.

Analytical Geometry—Text book: Peck's Analytical Geometry.
Graphics—Descriptive Geometry. Text book: Church's Descriptive Geometry.
Chemistry—Metals. Lectures, and "Fownes' Manual of Chemistry."
Blowpipe Analysis—Qualitative.
Zoology—Lectures, and Nicholson's Manual of Zoology.
Botany—Lectures, and Gray's Botanical Text Book.
French—Fasquelle's French Grammar; Beudant's Geologie; La bouchée de pain.
German—Text books: Wershoven's Technical Vocabulary; Stoehr's Katechismus der Bergbaukunde.
Drawing—Topographical drawing; tinting and grading; problems in graphics. Text book: Honey's Perspective.

Second Session.

Differential and Integral Calculus—Text book: Peck's Practical Calculus.
Graphics—Shades and Shadows, perspective, isometrical drawing. Text book: Church's Shades and Shadows.
Stone Cutting.

Chemistry—Organic. Lectures, and "Fownes' Manual of Chemistry."
Crystallography—Lectures, and "Egleston's Diagrams of Crystals."
Zoology—Lectures, and Nicholson's Manual of Zoology.
Botany—Lectures, and Gray's Botanical Text Book.
French—Text books: same as first session.
German—Text books: same as first session.
Drawing—Problems in graphics; architectural drawing.

SUMMER VACATION.

MEMOIR.

THIRD YEAR.

First Session.

Mechanics of Solids, including forces, moments, equilibrium, stability, etc., and elementary machines; dynamics, including uniform, varied, rectilineal and curvilinear motion, rotation, vibration, impact, work done, etc.

Engineering—General principles relating to materials and structures, physically and mechanically considered.

1. Materials—Stone, cements, brick, metals, timber, treated in regard to strength, durability, mode of preparation, defects, tests of quality, and fitness for special uses.
2. Structures—Foundations and supports, superstructure, joints, stability, strength and stiffness of parts; special rules of construction for masonry of public buildings, bridges, retaining walls, arches, railroads, common roads, and canals.
3. Theory of Strains and Strength of Materials—Elasticity, mechanical laws, application of principles of mechanics to beams, girders, and roof trusses under various conditions of loading and supports.

Kinematics of Machinery—(1) General theory of motion, (2) uniform and varied motion, (3) composition of motions, (4) instantaneous centre, (5) rolling centroids, (6) graphical and analytical representations of machine motions, (7) line of centres.

Surveying—Field work, with compass, sextant, hand level, and pacing, use of solar compass in land and mineral surveys, adjustments and use of transit and levelling instruments, triangulation and traversing.

Practical Mining or Miners' Work—Excavation, quarrying, drilling and blasting, tunnelling.

Applied Chemistry—Air, water, fuel, artificial illumination.

Quantitative Analysis.

Stoichiometry.

Mineralogy—Determinative.

Geology, Lithological—Rocks and rock masses.

Metallurgy—General metallurgy; fuel, furnaces, etc.

Physics—Mechanical theory of heat, electricity.

Drawing—Constructions; machines, furnaces, plans, etc.

Second Session.

Mechanics of Fluids, including pressure, buoyancy and specific gravities, motion in pipes and channels, undulation, capillarity, tension and elasticity of gases, the atmosphere, the barometer, barometric formulæ, and hypsometry.

Engineering—Theory of Strains and Strength of Materials continued—Graphical methods of determining strains, deflection of beams and girders; quantity of material in braced girders under various conditions of loading and supports; angle of economy for bracing torsion; of shafts; crushing and tensile strength of materials; working strains and working load; mode of estimating cost of girder work.

Dynamics of Machinery—Forces of nature employed or acting in all machines, dynamical laws, mathematical theorems, measure of forces, work of forces, elementary machines and their combinations, theory of efficiency,

theory of flywheels, governors and brakes, strength and proportions of parts of machines, dynamometers.

Transmissive Machinery—

1. Transmission by rolling contact, friction gear, and cams.
2. Transmission by sliding contact, spur, bevel screw, and skew-bevel teeth, and cams.
3. Transmission by shafting.
4. Transmission by belts, ropes, chains, etc.
5. Transmission by links.
6. Transmission by fluids.

Practical Mining, or Miners' Work—Excavation, quarrying, drilling and blasting, tunnelling.

Surveying—Topographical work with plane table, magnetic survey, underground surveying.

Physics—Physical optics and the undulatory theory of light.

Applied Chemistry—Limes, mortars, and cements; building stones: decay and preservation; timber and its preservation: pigments, paints, essential oils, varnishes; glass and ceramics; explosives: gunpowder, guncotton, nitroglycerine, etc.

Quantitative Analysis.

Mineralogy—Determinative.

Metallurgy—Iron and steel.

Geology—Historical, including palæontology, or a systematic review of recent and fossil forms of life.

Drawing—Constructions; machines, furnaces, plans, etc.

SUMMER VACATION.

MEMOIR.

FOURTH YEAR.

(*Without distinction of Sessions.*)

Dynamics of Machinery, completed—Prime Movers, as driven by animal power, water power, steam power, compressed or heated air, wind power, comprising the theory of animal power, theory of water wheels, overshot wheels, undershot wheels, breast wheels, turbines, reaction wheels, centrifugal pumps; properties and laws of heat as applied to the generation of steam and the construction of boilers; properties of steam and air in their relation to prime movers; mechanical theory of heat applied to steam engines, hot air engines, compressed air engines; general description of heat engines of various forms; description and theory of ventilating fans or blowers.

Mining Engineering—

1. Considered in its widest sense as a course of study.
2. Considered in reference to the application of general principles of engineering to the development and working of mines.
3. Classification and nomenclature of mineral deposits; descriptions of lodes or veins, beds, masses, and irregular deposits, with illustrations of the disturbances to which they are subjected, as affecting the work of mining.
4. Graphical representations of deposits, with examples showing modes of occurrence and disturbances.
5. Prospecting or searching for mineral deposits.
6. Exploratory workings.
7. Establishing seats of extraction.

8. Description of typical methods of exploitation as applied to wide veins or lodes, to narrow veins, masses, to beds of various thickness and degrees of inclination.
9. General principles relating to subterranean transportation.
10. Methods and machinery employed for extracting minerals from the pits, and for facilitating ascent and descent of workmen.
11. Drainage of mines; theory of infiltrations of water, methods and machinery for draining or freeing mines from water.
12. Ventilation of mines; causes of vitiation of the air of mines; quantities of fresh air required under various circumstances; natural ventilation; mechanical ventilation, by fires and by ventilating machinery; distribution of air through galleries and workings.
13. Graphical illustrations of exploratory workings; methods of exploitation; machinery for hoisting, pumping, ventilation, and transportation, including the use of steam engines and pumps, air compressors, air engines, pumping engines, winding engines, centrifugal, and other ventilating machines.

Practical Mining—

1. Boring, earth augers, driven wells, boring with rods and cable tools, upward, inclined, and horizontal boring, diamond drill and its use in prospecting.
2. Shaft sinking, shaft timbering and spiling, boring of shafts, sinking of iron and masonry linings, cribbing, walling, and tubbing.
3. Drifting of adits and levels, timbering and walling in levels and working places.
4. Mining of coal and ores, coal cutting machines, hand and machine drilling.
5. Handling of coal and ores in working places.
6. Tramming, cars, tracks, locomotive and wire rope haulage, planes and gravity roads.

7. Accidents to miners, cause and prevention.
8. Organization and administration.
9. Time books, measurement of contracts, pay roll, analysis and dissection of accounts, and cost sheets.

Ore Dressing—

1. Introduction, theory of separation, hand and machine dressing, general principles governing crushing and sizing of ores of different character.
2. Jigging—theory of, description of different forms of jigs and methods of working, air jigs.
3. Slime treatment, classification of slimes in troughs, spitz kasten, etc., and treatment on buddles and tables.
4. Description of crushing machinery, jaw crushers, rolls, stamps, mills, etc.
5. Sizing apparatus, screens, riddles, and trommels.
6. Description of coal washing plant; anthracite breaker.
7. Description of American ore-dressing works.
8. Foreign ore-dressing works.

Hydraulic Engineering—Application of principles of mechanics of fluids to determining the discharge of water over weirs or dams; the dimensions of conduit pipes; discharge of canals and rivers; the effect of varying forms and sections of channels and of obstructions to flow; the gauging of streams; retaining walls for reservoirs.

Mechanical Engineering—

1. Steam boilers—construction, wear and tear, fittings, setting, testing, care and management, firing, feeding, injectors, pumps, etc.
2. Mechanism of engines—Valve gearing, link motions, governors, etc.
3. Management of engines—Erecting, emergencies, special types of engines, etc.
4. Proportions of engines, etc.
5. Testing efficiency of engines and boilers, etc.

6. Pumps, hoisting engines, ventilating machinery, construction and management of hot air, gas, and petroleum engines, etc.
7. Machine tools.

Physical properties of Materials—Pig iron: castings, chilled and malleable; wrought iron: bar, shapes, plate, tube, and wire; steel: ingot metal, castings, shapes, and plate; other metals and alloys.

Surveying—Railroad surveying, reconnoissance, location of line, calculation of cuttings and embankments.

Economic Geology—Theory of mineral veins, ores, deposits and distribution of iron, copper, lead, gold, silver, mercury, and other metals; graphite, coal, lignite, peat, asphalt, petroleum, salt, clay, limestone, cements, building and ornamental stones, etc.

Assaying—Ores of lead, silver, gold; and gold, silver, and lead alloys.

Metallurgy—Copper, lead, antimony, silver, gold, zinc, tin, mercury, etc.

Drawing—Graphic statics and project.

Project.

II.—COURSE IN CIVIL ENGINEERING.

SECOND YEAR.

First Session.

Analytical Geometry—Text book: Peck's Analytical Geometry.

Graphics—Descriptive Geometry. Text book: Church's Descriptive Geometry.

Chemistry—The Metals. Lectures, and "Fownes' Manual of Chemistry."

Blowpipe Analysis—Qualitative. Text book: Plattner's Blowpipe Analysis.

Zoology—Lectures, and Nicholson's Manual of Zoology.

Botany—Lectures, and Gray's Botanical Text Book.

French—Text books: Fasquelle's French Grammar; Beudant's Geologie; La bouchée de pain.
German—Text books: Wershoven's Technical Vocabulary Bernoulli's Vademecum des Mechanikers.
Drawing—Topographical Drawing; tinting and grading problems in graphics. Text book: Honey's Perspective.

Second Session.

Differential and Integral Calculus—Text book: Peck's Practical Calculus.
Graphics—Shades and shadows, perspective, isometrical drawing. Text book: Church's Shades and Shadows
Stone Cutting.
Chemistry—Organic. Lectures, and "Fownes' Manual o Chemistry."
Crystallography—Lectures, and Egleston's Diagrams o Crystals.
Zoology—Lectures, and Nicholson's Manual of Zoology.
Botany—Lectures, and Gray's Botanical Text Book.
French—Text books: same as first session.
German—Text books: same as first session.
Drawing—Problems in graphics; architectural drawing.

SUMMER VACATION.

MEMOIR.

THIRD YEAR.

First Session.

Mechanics of Solids, including forces, moments, equilibrium, stability, etc., and elementary machines; dynamics, including uniform, varied, rectilineal and curvilinear motion, rotation, vibration, impact, work done etc.
Engineering—General principles relating to materials and structures, physically and mechanically considered.

1. Materials—Stone, cements, brick, metals, timber, treated in regard to strength, durability, mode of preparation, defects, tests of quality, and fitness for special uses.
2. Structures—Foundations and supports, superstructure, joints, strength and stiffness of parts; special rules of construction for masonry of public buildings, bridges, retaining walls, arches, railroads, common roads and canals.
3. Theory of Strains and Strength of Materials—Elasticity, mechanical laws, application of principles of mechanism to beams, girders, and roof trusses under various conditions of loading and supports.

Kinematics of Machinery—(1) General theory of motion, (2) uniform and varied motion, (3) composition of motions, (4) instantaneous centre, (5) rolling centroids, (6) graphical and analytical representations of machine motions, (7) line of centres.

Practical Mining—Excavation, quarrying, drilling and blasting, tunnelling.

Practical Astronomy and General Principles of Geodesy.

Surveying—Field work, with compass, sextant, hand level, and pacing, use of solar compass in land surveys, adjustments and use of transit and levelling instruments, triangulation and traversing.

Applied Chemistry—Air, water, fuel, artificial illumination.

Mineralogy—Determinative.

Geology—Lithological, cosmical, and physiographic.

Metallurgy—General metallurgy; fuels, furnaces, etc.

Physics—Mechanical theory of heat, electricity.

Drawing—Constructions; machines, furnaces, plans, etc.

Second Session.

Mechanics of Fluids, including pressure, buoyancy and specific gravities, motion in pipes and channels, undulation, capillarity, tension and elasticity of gases, the atmosphere, the barometer, barometric formulæ, and hypsometry.

Engineering—Theory of Strains and Strength of Materials continued—Graphical methods of determining strains; deflection of beams and girders; quantity of material in braced girders under various conditions of loading and supports; angle of economy for bracing; torsion of shafts; crushing and tensile strength of materials; working strains and working load; mode of estimating cost of girder work.

Dynamics of Machinery—Forces of nature employed or acting in all machines, dynamical laws, mathematical theorems, measure of forces, work of forces, elementary machines and their combinations, theory of efficiency, theory of flywheels, governors and brakes, strength and proportions of parts of machines, dynamometers.

Transmissive Machinery—

1. Transmission by rolling contact, friction gear, and cams.
2. Transmission by sliding contact, spur, bevel screw, and skew-bevel teeth, and cams.
3. Transmission by shafting.
4. Transmission by belts, ropes, chains, etc.
5. Transmission by links.
6. Transmission by fluids.

Practical Mining—Excavation, quarrying, drilling and blasting, tunnelling.

Practical Astronomy and general principles of Geodesy.

Surveying--Topographical work with plane table.

Physics—Physical optics and the undulatory theory of light.

Applied Chemistry—Limes, mortars, and cements; building stones: decay and preservation; timber and its preservation: pigments, paints, essential oils, varnishes; glass and ceramics; explosives: gunpowder, gun-cotton, nitroglycerine, etc.

Mineralogy—Determinative.

Metallurgy—Iron and steel.

Geology—Historical, including palæontology.

Drawing—Constructions; machines, furnaces, plans, etc.

SUMMER VACATION.

MEMOIR.

FOURTH YEAR.

(*Without distinction of Sessions.*)

Dynamics of Machinery completed—Prime movers as driven by animal power, water power, steam power, compressed or heated air, wind power, comprising the theory of animal power, theory of water wheels, overshot wheels, undershot wheels, breast wheels, turbines, reaction wheels, centrifugal pumps; properties and laws of heat as applied to the generation of steam in steam boilers; properties of steam and air in their relation to prime movers; mechanical theory of heat, applied to steam engines, hot-air engines, compressed-air engines; general description of heat engines of various forms; description and theory of ventilating fans or blowers.

Civil Engineering—Hydraulic and Sanitary Engineering, embracing water supply for cities and towns, for the purposes of irrigation and improvement of lands; quantity and quality of water required; rainfall, flows of streams, storage of water, capacity of water sheds, impurities of water; practical construction of water works, pumping machinery; clarification of water; systems of water supply.

Principles of Sanitary Engineering as regards necessity of sanitary measures, different systems of removing refuse and decomposing matters, warming and ventilation.

Works of Sewerage—Rainfall and sewers; influence of geological and topographical features of the sites of towns and districts; discharge of sewers; intercepting sewers; forms, modes of construction, and materials used; flushing of sewers and ventilation; traps, out-

falls, tide valves; subsoil and surface drainage of towns house drainage; water-closets; ventilation of houses, in connection with sanitary measures.

Improvements of Rivers and Harbors—Action of tides and currents in forming and removing deposits; methods of protecting and deepening harbors and channels.

Geodesy continued, with lectures on figure of the earth, and practical illustration in the use of geodetic instruments, such as measurement of base lines, measurement of horizontal angles for a primary, a secondary, and a tertiary triangulation; signals, astronomical determinations of time, latitude, longitude, and azimuth of a direction.

Railroad Engineering—Permanent way; rolling stock; motive power; administration, etc.

Hydraulic Engineering—Application of principles of mechanics of fluids to determining the discharge of water over weirs or dams; the dimensions of conduit pipes; discharge of canals and rivers; the effects of varying forms and sections of channels and of obstructions to flow; the gauging of streams; retaining walls for reservoirs.

Mechanical Engineering—(1) steam boilers: construction, wear and tear, fittings, setting, testing, care and management, firing, feeding, injectors, pumps, etc.; (2) mechanism of engines, valve gearing, link motions, governors, etc.; (3) management of engines, erecting, emergencies, special types of engines, etc.; (4) proportions of engines, etc.; (5) testing efficiency of engines and boilers; (6) pumps, hoisting engines, ventilating machinery; (7) construction and management of hot air, gas, and petroleum engines, etc.; (8) machine tools.

Physical Properties of Materials—Pig iron: castings, chilled and malleable; wrought iron: bar, shapes, plate, tube, and wire; steel: ingot metal, castings, shapes, and plate; other metals and alloys.

Surveying—Railroad surveying: reconnoissance, location and survey of line with curves and slope stakes, calculations of cuttings and embankments.

Economic Geology—Theory of mineral veins, ores, deposits and distribution of iron, copper, lead, gold, silver, mercury, and other metals; graphite, coal, lignite, peat, asphalt, petroleum, salt, clay, limestone, cements, building and ornamental stones, etc.

Drawing—Graphic statics and project.

Project.

III.—COURSE IN METALLURGY.

SECOND YEAR.

First Session.

Analytical Geometry—Text book: Peck's Analytical Geometry.

Graphics—Descriptive Geometry. Text book: Church's Descriptive Geometry.

Chemistry—The Metals. Lectures and "Fownes' Manual of Chemistry."

Quantitative Analysis—Lectures and "Cairn's Quantitative Analysis."

Stoichiometry.

Blowpipe Analysis—Qualitative. Text book: Plattner's Blowpipe Analysis.

Zoology—Lectures, and Nicholson's Manual of Zoology.

Botany—Lectures, and Gray's Botanical Text Book.

French—Text books: Fasquelle's French Grammar; Beudant's Geologie; La bouchée de pain.

German—Text books: Wershoven's Technical Vocabulary; Gurlt's Bergbau- und Huettenkunde.

Drawing—Tinting and grading; topographical drawing; problems in graphics. Text book: Honey's Perspective.

Second Session.

Differential and Integral Calculus—Text book: Peck's Practical Calculus.

Graphics—Shades and Shadows, perspective, isometrical drawing. Text book: Church's Shades and Shadows.

Stone Cutting.

Chemistry—Organic. Lectures, and "Fownes' Manual of Chemistry."

Quantitative Analysis—Lectures, and "Cairn's Quantitative Analysis."

Crystallography—Lectures, and illustrative diagrams.

Zoology—Lectures, and Nicholson's Manual of Zoology.

Botany—Lectures, and Gray's Botanical Text Book.

French—Text books: same as first session.

German—Text books: same as first session.

Drawing—Problems in graphics; architectural drawing.

SUMMER VACATION.

MEMOIR.

THIRD YEAR.

First Session.

Mechanics of solids, including forces, moments, equilibrium, stability, etc., and elementary machines; dynamics, including uniform, varied, rectilineal and curvilinear motion, rotation, vibration, impact, work done, etc.

Quantitative Analysis.

Kinematics of machinery—(1) General theory of motion, (2) uniform and varied motion, (3) composition of motions, (4) instantaneous centre, (5) rolling centroids, (6) graphic and analytical representations of machine motions, (7) line of centres.

Applied Chemistry—Air, water, fuel, artificial illumination.

Mineralogy—Determinative.

Geology—Lithological, cosmical, physiographic.
Metallurgy—General Metallurgy; fuel, furnaces, etc.
Physics—Mechanical theory of heat, electricity.
Drawing—Constructions; machines, furnaces, plans, etc.

Second Session.

Mechanics of Fluids, including pressure, buoyancy and specific gravities, motion in pipes and channels, undulation, capillarity, tension and elasticity of gases, the atmosphere, the barometer, barometric formulæ, and hypsometry.

Physics—Physical optics and the undulatory theory of light.

Dynamics of Machinery—Forces of nature employed or acting in all machines, dynamical laws, mathematical theorems, measure of forces, work of forces, elementary machines and their combinations, theory of efficiency, theory of flywheels, governors and brakes, strength and proportions of parts of machines, dynamometers.

Transmissive Machinery—

1. Transmission by rolling contact, friction gear, and cams.
2. Transmission by sliding contact, spur, bevel screw, and skew-bevel teeth, and cams.
3. Transmission by shafting.
4. Transmission by belts, ropes, chains, etc.
5. Transmission by links.
6. Transmission by fluids.

Applied Chemistry—Limes, mortars, and cements; building stones: decay and preservation; timber and its preservation: pigments, paints, essential oils, varnishes; glass and ceramics; explosives: gunpowder, guncotton, nitroglycerine, etc.

Quantitative Analysis.
Mineralogy—Determinative.
Metallurgy—Iron and steel.
Geology—Historical, including palæontology.
Drawing—Constructions; machines, furnaces, plans, etc.

SUMMER VACATION.

MEMOIR.

FOURTH YEAR.

(*Without distinction of Sessions.*)

Machines, including prime movers, as driven by (1) animal power, (2) water power, (3) steam, (4) heated or compressed air, (5) the winds; comprising water wheels, turbines, and reaction wheels, steam engines in their various forms, and air engines.

Principles of Heat applicable to these Engines.

Steam Boilers.

Mechanism and Management of Engines.

Machine Tools.

Ore Dressing—

1. Introduction, theory of separation, hand and machine dressing, general principles governing crushing and sizing of ores of different character.
2. Jigging—theory of, description of different forms of jigs and methods of working, air jigs.
3. Slime treatment, classification of slimes in troughs, spitz kasten, etc., and treatment on buddles and tables.
4. Description of crushing machinery, jaw crushers, rolls, stamps, mills, etc.
5. Sizing apparatus, screens, riddles, and trommels.
6. Description of coal washing plant; anthracite breaker.
7. Description of American ore-dressing works.
8. Foreign ore-dressing works.

Assaying—Ores of lead, silver, gold, platinum, tin, antimony, bismuth, copper, nickel, cobalt, iron, mercury, and zinc; and gold, silver, and lead bullion; mattes, slags, etc.

Metallurgy—Copper, lead, silver, gold, zinc, tin, mercury, etc.

Economic Geology—Theory of mineral veins, ores, deposits and distribution of iron, copper, lead, gold, silver, mercury, and other metals; graphite, coal, lignite, peat, asphalt, petroleum, salt, clay, limestone, cements, building and ornamental stones, etc.

Applied Chemistry—I. Chemical manufactures: acids, alkalies, and salts. (1) Sulphur, sulphurous acid, hyposulphites, sulphuric acid, bisulphide of carbon, etc. (2) Common salt, soda ash, hydrochloric acid, chlorine, binoxide of manganese, bleaching powder, chlorates, chlorimetry, etc. (3) Carbonate of potash, caustic potash, alkalimetry, acidimetry, etc. (4) Nitric acid and nitrates. (5) Iodine, bromine, etc. (6) Sodium, aluminium, magnesium. (7) Phosphorus, matches, etc. (8) Ammonia salts. (9) Cyanides. (10) Alum, copperas, blue vitriol, salts of magnesia, baryta, strontia, etc. (11) Borates, stannates, tungstates, chromates, etc. (12) Mercury salts, silver salts, photography. (13) Electrometallurgy. (14) Oils, fats, soaps, glycerine. II. Food and drink: milk, cereals, starch, bread, meat, tea, coffee, sugar, fermentation, wine, beer, spirits, vinegar, preservation of food, tobacco, etc. III. Clothing: textile fabrics, bleaching, dyeing, calico printing, paper, tanning, glue, India-rubber, gutta percha, etc. IV. Fertilizers: guano, superphosphates, poudrettes, etc.

Drawing—Project and thesis work.

Project.

IV.—COURSE IN GEOLOGY AND PALÆONTOLOGY.

SECOND YEAR.

First Session.

Graphics—Descriptive Geometry. Text book: Church's Descriptive Geometry.

Chemistry—The Metals. Lectures, and "Fownes' Manual of Chemistry."

Quantitative Analysis—Lectures, and "Cairn's Quantitative Analysis."

Stoichiometry.
Blowpipe Analysis—Qualitative. Text book: Plattner's Blowpipe Analysis.
Zoology—Lectures, and Nicholson's Manual of Zoology.
Botany—Lectures, and Gray's Botanical Text Book.
French—Text books: Fasquelle's French Grammar; Beudant's Geologie; La bouchée de pain.
German—Text books: Wershoven's Technical Vocabulary; Gurlt's Bergbau- und Huettenkunde.
Drawing—Topographical drawing; tinting and grading; problems in graphics. Text book: Honey's Perspective.

Second Session.

Graphics—Shades and shadows, perspective and isometrical drawing. Text book: Church's Shades and Shadows.
Chemistry—Organic. Lectures, and "Fownes' Manual of Chemistry."
Quantitative Analysis—Lectures, and Cairn's Quantitative Analysis.
Crystallography—Lectures and illustrative diagrams.
Botany—Lectures, and Nicholson's Manual of Zoology.
Zoology—Lectures, and Gray's Botanical Text Book.
French—Text books: same as first session.
German—Text books: same as first session.
Drawing—Problems in graphics.

SUMMER VACATION.

MEMOIR.

THIRD YEAR.

First Session.

Geology—Lithological, cosmical, physiographic.
Surveying, with compass, sextant, hand level, and pacing, use of solar compass in land and mineral surveys, adjustments and use of transit and levelling instruments, triangulation and traversing.

Applied Chemistry—Air, water, fuel, artificial illumination.
Quantitative Analysis.
Stoichiometry.
Mineralogy—Determinative.
Metallurgy—General metallurgy, fuels, etc.
Physics—Mechanical theory of heat, electricity.
Drawing—Geological drawings.

Second Session.

Geology—Historical, including palæontology.
Surveying—Topographical work with plane table, magnetic survey.
Physics—Physical optics and the undulatory theory of light.
Applied chemistry—Limes, mortars, and cements; building stones: decay and preservation; timber and its preservation: pigments, paints, essential oils, varnishes; glass and ceramics; explosives: gunpowder, guncotton, nitroglycerine, etc.
Quantitative Analysis.
Mineralogy—Determinative.
Metallurgy—Iron and steel.
Drawing—Geological drawings.

SUMMER VACATION.

MEMOIR.

FOURTH YEAR.

(*Without distinction of Sessions.*)

Economic Geology—Theory of mineral veins, ores, deposits and distribution of iron, copper, lead, gold, silver, mercury, and other metals; graphite, coal, lignite, peat, asphalt, petroleum, salt, clay, limestone, cements, building and ornamental stones, etc.
Surveying—Principles of Geodesy; Railroad surveying: reconnoissance, location of line, calculations of cuttings and embankments.

Metallurgy—Copper, lead, silver, gold, zinc, tin, mercury, etc.
Drawing—Dissertation and thesis work.
Dissertation.

V.—COURSE IN ANALYTICAL AND APPLIED CHEMISTRY.

SECOND YEAR.

First Session.

Graphics—Descriptive Geometry. Text book: Church's Descriptive Geometry.
Chemistry—The Metals. Lectures, and "Fownes' Manual of Chemistry."
Quantitative Analysis—Lectures, and "Cairn's Quantitative Analysis."
Stoichiometry.
Blowpipe Analysis—Qualitative. Text book: Plattner's Blowpipe Analysis.
Zoology—Lectures, and Nicholson's Manual of Zoology.
Botany—Lectures, and Gray's Botanical Text Book.
French—Text books: Fasquelle's French Grammar; Beudant's Geologie; La bouchée de pain.
German—Text books: Wershoven's Technical Vocabulary; Stoeckhardt's Schule der Chemie.
Drawing—Topographical drawing; tinting and grading; problems in graphics. Text book: Honey's Perspective.

Second Session.

Graphics—Shades and shadows, perspective and isometrical drawing. Text book: Church's Shades and Shadows.
Chemistry—Organic. Lectures, and "Fownes' Manual of Chemistry."
Quantitative Analysis—Lectures, and "Cairn's Quantitative Analysis."

Crystallography—Lectures, and Egleston's Diagrams of Crystals.
Zoology—Lectures, and Nicholson's Manual of Zoology.
Botany—Lectures, and Gray's Botanical Text Book.
French—Text books: same as first session.
German—Text books: same as first session.
Drawing—Problems in graphics.

SUMMER VACATION.

MEMOIR.

THIRD YEAR.

First Session.

Applied Chemistry—Air, water, fuel, artificial illumination.
Quantitative Analysis.
Mineralogy—Determinative.
Geology—Lithological, cosmical, physiographic.
Metallurgy—General metallurgy, fuels, furnaces, etc
Physics—Mechanical theory of heat, electricity.

Second Session.

Applied Chemistry—Limes, mortars, and cements; building stones: decay and preservation; timber and its preservation: pigments, paints, essential oils, varnishes; glass and ceramics; explosives: gunpowder, guncotton, nitroglycerine, etc.
Quantitative Analysis.
Mineralogy—Determinative.
Geology—Historical, including palæontology.
Metallurgy—Iron and steel.
Physics—Physical optics and the undulatory theory of light.

SUMMER VACATION.

MEMOIR.

FOURTH YEAR.

(*Without distinction of Sessions.*)

Applied Chemistry—I. Chemical manufactures : acids, alkalies, and salts. (1) Sulphur, sulphurous acid, hyposulphites, sulphuric acid, bisulphide of carbon, etc. (2) Common salt, soda ash, hydrochloric acid, chlorine, binoxide of manganese, bleaching powder, chlorates, chlorimetry, etc. (3) Carbonate of potash, caustic potash, alkalimetry, acidimetry, etc. (4) Nitric acid and nitrates. (5) Iodine, bromine, etc. (6) Sodium, aluminium, magnesium. (7) Phosphorus, matches, etc. (8) Ammonia salts. (9) Cyanides. (10) Alum, copperas, blue vitriol, salts of magnesia, baryta, strontia, etc. (11) Borates, stannates, tungstates, chromates, etc. (12) Mercury salts, silver salts, photography. (13) Electrometallurgy. (14) Oils, fats, soaps, glycerine. II. Food and drink : milk, cereals, starch, bread, meat, tea, coffee, sugar, fermentation, wine, beer, spirits, vinegar, preservation of food, tobacco, etc. III. Clothing : textile fabrics, bleaching, dyeing, calico printing, paper, tanning, glue, India-rubber, gutta percha, etc. IV. Fertilizers : guano, superphosphates, poudrettes, etc.

Organic Chemistry—Laboratory practice.

Assaying—Ores of lead, silver, gold, platinum, tin, antimony, bismuth, copper, nickel, cobalt, iron, mercury, and zinc ; and gold, silver, and lead bullion; mattes, slags, etc.

Metallurgy—Copper, lead, silver, gold, zinc, tin, mercury, etc.

Economic Geology—Theory of mineral veins, ores, deposits and distribution of iron, copper, lead, gold, silver, mercury, and other metals ; graphite, coal, lignite, peat, asphalt, petroleum, salt, clay, limestone, cements, building and ornamental stones, etc.

Dissertation.

V.—COURSE IN ARCHITECTURE.

SECOND YEAR.

First Session.

Analytical Geometry—Text book : Peck's Analytical Geometry.
Graphics—Descriptive Geometry. Problems.
Chemistry—The Metals. Lectures, and "Fownes' Manual of Chemistry."
The Elements of Architecture—The forms and proportions of the five orders, and of balustrades, steps, doors, windows, arches, vaults, domes, roofs, spires, etc.
Greek Architectural History—Text book : Reber's History of Ancient Art.
French—Text books: Fasquelle's French Grammar ; Beudant's Geologie ; La bouchée de pain.
German—Text books : Wershoven's Technical Vocabulary; Bernoulli's Vademecum des Mechanikers.
Drawing—Tracing ; ornament ; plans, sections, and elevations.

Second Session.

Differential and Integral Calculus—Text book : Peck's Practical Calculus.
Graphics—Shades and shadows ; perspective, isometrical drawing. Problems.
Stone Cutting.
The Elements of Architecture, continued.
Roman Architectural History.
French—Text books : same as first session.
German—Text books : same as first session.
Drawing—Ornament from casts; details; perspective drawings.

SUMMER VACATION.

MEMOIR.

THIRD YEAR.

First Session.

Mechanics of Solids, including forces, moments, equilibrium, stability, etc., and elementary machines.

Engineering—General principles relating to materials and structures, physically and mechanically considered.

1. Materials—Stone, cements, brick, metals, timber, treated in regard to strength, durability, mode of preparation, defects, tests of quality, and fitness for special uses.
2. Structures—Foundations and supports, superstructure, joints, stability, strength, and stiffness of parts; special rules of construction for masonry of public buildings, bridges, retaining walls, arches, railroads, common roads, and canals.
3. Theory of Strains and Strength of Materials—Elasticity, mechanical laws, application of principles of mechanics to beams, girders, and roof trusses under various conditions of loading and supports.

Applied Chemistry—Air, water, fuel, artificial illumination.

Geology—Descriptive.

* Mediæval Architectural History.

* The History of Ornament—Lectures and exercises.

* The Decorative Arts—Terra cotta, faïence, stained glass, enamels, mosaic, fresco, distemper. Lectures and sketching. Excursions.

* Specifications and working drawings—Excavation, foundations, piling, stone work, brick work, plastering, and stucco work. Lectures and laboratory work. Excursions.

Architectural Design—Design by dictation. Problems.

Modelling.

Drawing from the Cast—Ornament and the human figure.

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* For convenience these subjects are given in alternate years, the third and fourth year students taking them together.

Second Session.

Mechanics of Solids—Dynamics, including uniform, varied, rectilineal and curvilinear motion, rotation, vibration, impact, work done, etc.

Engineering—Theory of Strains and Strength of Materials continued—Graphical methods of determining strains, deflection of beams and girders; quantity of material in braced girders under various conditions of loading and supports; angle of economy for bracing; torsion of shafts; crushing and tensile strength of materials; working strains and working load; mode of estimating cost of girder work.

Applied Chemistry—Limes, mortars, and cements; building stones: decay and preservation; timber and its preservation: pigments, paints, oils, and varnishes; glass and ceramics; explosives: gunpowder, guncotton, nitro-glycerine, etc

Geology—Historical.

* Mediæval Architectural History.

* The History of Ornament—Lectures and blackboard exercises.

* The Decorative Arts—Embroidery, weaving, jewelry, metal work, inlays. Lectures and sketching. Excursions.

* Specifications and working drawings — Carpentry, painting, glazing, plumbing; iron, lead, and copper work; tinning and slating. Lectures and laboratory work. Excursions.

Architectural design. Alterations and Restorations—Problems.

Drawing—Water colors.

SUMMER VACATION.

MEMOIR.

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* For convenience these subjects are given in alternate years, the third and fourth year students taking them together.

FOURTH YEAR.

(*Without distinction of Sessions.*)

Sanitary Engineering.
Sewerage.
Economic Geology—Clay, limestone, cements, building and ornamental stones.
Graphical Statics.
Book-keeping—Time books, contracts, pay rolls, analysis of accounts, and cost sheets.
* Business relations between architects, clients, mechanics, and draughtsmen; office papers; competitions; legal obligations; superintendence.
* Estimates—Quantity, weight, time, labor, cost; squaring.
* Modern Architectural History.
* The History of Painting and Sculpture.
* The Theory of Architecture—The theory of form, the theory of color, the theory of composition.
Literature and Criticism—Themes, Reports. Abstracts of books.
Architectural Design—Problems.
Project.

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* For convenience these subjects are given in alternate years, the third and fourth year students taking them together.

DEPARTMENTS OF INSTRUCTION.

MODERN LANGUAGES.

The design in this department is to teach the students to read French and German scientific books with facility.

Instruction is given for three hours a week in each of these languages during the first year and two hours a week during the second year. As the text-books employed in the class-room are altogether works on science, the students can acquire a sufficient vocabulary to enable them to use French and German authors in all the departments of the school.

No attempt is made to produce accomplished scholars in all branches of German and French literature, but attention is concentrated upon the immediate wants of the young men. In this way no time is lost, and the instruction is made thoroughly practical.

MATHEMATICS.

The students of the first class attend four hours per week throughout the year. In the first session, they complete the subject of Geometry, plane, volumetric, and spherical; the parabola, ellipse and hyperbola, geometrically treated; and Algebra, including the general principles and properties of logarithms and the logarithmic series, the general theory of equations, embracing the principal transformations and properties, derived equations and equal roots, Sturm's theorem and the solution of higher equations. In the second session they are taught Trigonometry, plane, analytical, and spherical, with the solution of many practical problems by formulæ and by construction; and the Mensuration of surfaces and of volumes.

The students of the Second Class attend four hours per week throughout the year. In the first session, they complete the subject of Analytical Geometry, with applications to lines and surfaces of the second order; and in the second, the Differential and Integral Calculus, with some of its applications to mechanics and astronomy, as centre of gravity, moment of inertia, falling bodies, attraction of homogeneous spheres, orbital motion, law of force, etc.

MECHANICS.

This subject is taught during the third year. The course of instruction embraces the following subjects:

Representation and measurement of forces; composition, resolution, and equilibrium of forces; principles of moments and virtual moments; theory of parallel forces; application to centre of gravity; stability.

Elementary machines: friction, resistance to rolling, stiffness of cords, atmospheric resistance.

General equations of motion: rectilineal, uniform, and uniformly varied motion; curvilinear motion, free and constrained; centrifugal force; application to the governor; vibratory motion; application to the pendulum; motions of translation and rotation; moment of inertia, principal axes, and ellipsoid of inertia; laws of impact; centre of percussion; general theorem of work; accumulation of work; application to fly-wheel.

Mechanics of fluids: pressure due to weight; equal transmission of pressures; application to hydraulic press; buoyancy and flotation; application to specific gravity.

Tension and elasticity of gases and vapors: laws of variation; application to pumps and siphons; investigation of the barometer formula; motion of liquids in pipes and open channels; living force of fluids; application to hydraulic ram; mechanics of capillarity.

Practical Astronomy and Geodesy.—Students of the Third and Fourth Classes in the course of Civil Engineering are required to attend the course of Practical

Astronomy and Geodesy. This course includes the theory and use of the transit and sextant, and the determination of geographical position ; also the theory and use of geodetic instruments.

PHYSICS.

The students of the First Class are occupied during the first term with the subject of heat, including the steam engine, and with acoustics; during the second term, in the study of optics, voltaic electricity, magnetism, and electro-magnetism. The courses are fully illustrated by appropriate experiments, and practical problems are occasionally proposed for solution.

To the students of the Third Class, courses of lectures are delivered on the laws of electro-statics, on the mechanical theory of heat, on mathematical optics, and on the undulatory theory of light. Portions of these courses are accompanied by experimental demonstrations.

The cabinet of physical apparatus will rank with the best on this continent, and extensive additions are made to it each year.

CHEMISTRY.

I. General Chemistry.—The First Class attends three exercises a week in the general chemistry of the non-metallic elements throughout the year. It is intended to lay the foundation of a thorough knowledge of the theory of the subject preliminary to the practical instruction in the chemical laboratory. For this purpose the students are drilled upon the lectures, with free use of a text book. They are expected to write out full notes. At the end of the year, they must pass a rigid examination before being admitted to a higher grade.

The Second Class also attends three times a week during the year, and receives instruction in theoretical chemistry adapted to the wants of special scientific students. In the first session, the chemistry of the metals ; in the second session, organic chemistry.

II. Analytical Chemistry. — There is a laboratory devoted to qualitative analysis, another to quantitative analysis, and an assay laboratory. These laboratories are provided with all the necessary apparatus and fixtures, and each is under the special charge of a competent instructor with an assistant. Each student is provided with a convenient table, with drawers and cupboards, and is supplied with a complete outfit of apparatus and chemical reagents.

During the first year, qualitative analysis is taught by lectures and blackboard exercises, and the student is required to repeat all the experiments at his table in the laboratory. Having acquired a thorough experimental knowledge of the reactions of a group of bases or acids, single members of the group or mixtures are submitted to him for identification. He thus proceeds from simple to complex cases till he is able to determine the composition of the most difficult mixtures.

When the student shows, on written and experimental examination, that he is sufficiently familiar with qualitative analysis, he is allowed to enter the quantitative laboratory.

During the second and third years, quantitative analysis is taught by lectures, and the student is required to execute in the laboratory in a satisfactory manner a certain number of analyses. He first analyzes substances of known composition, such as crystallized salts, that the accuracy of his work may be tested by a comparison of his results with the true percentages.

These analyses are repeated till he has acquired sufficient skill to insure accurate results. He is then required to make analyses of more complex substances, such as coals, limestones, ores of copper, iron, zinc and nickel, pig iron, slags, technical products, etc.—cases in which the accuracy of the work is determined by duplicating the analyses and by comparing the results of different analyses.

Volumetric methods are employed whenever they are more accurate or more expeditious than the gravimetric

methods. In this way each student acquires practical experience in the chemical analysis of the ores and products which he is most likely to meet in practice.

III. Organic Chemistry.—Organic chemistry is taught by lectures in the second session of the second year. During the fourth year the students in the course of Analytical and Applied Chemistry devote their time in the laboratory to organic chemistry.

IV. Stoichiometry.—Stoichiometry, the arithmetic of chemistry, is taught by lectures and blackboard exercises as a part of the course of instruction in general chemistry in the first and second years; and its practical applications are developed in lectures on quantitative analysis and assaying.

V. Assaying.—During the fourth year, the student is admitted to the assay laboratory, where he is provided with a suitable table and a set of assay apparatus, and where he has access to crucible and muffle furnaces, and to volumetric apparatus for the assay of alloys of gold and silver.

The general principles as well as the special methods of assaying are explained in the lecture room, and at the same time the ores of the various metals and their appropriate fluxes are exhibited and described.

The student is then supplied with the different ores, and is required to assay each one in duplicate under the immediate supervision of the instructor.

To facilitate the assay of ores of the precious metals a system of weights has been introduced, by which the weight of the silver or gold globule obtained shows at once, without calculation, the number of troy ounces in a ton of ore.

Students are also given an opportunity of testing the milling qualities of gold and silver ores, and are required to give special attention to sampling and the mechanical assaying of the ores of the precious metals.

VI. Applied Chemistry.—The instruction in applied chemistry extends through the third and fourth years, and consists of lectures illustrated by experiments diagrams, and specimens.

The subjects discussed are :

IN THE THIRD YEAR.

(For all students.)

I. Air : nature, sources of contamination, sewer gas, plumbing, drainage, disinfection, ventilation.
II. Water : composition of natural waters, pollution, disposal of sewage and house refuse.
III. Fuel and its applications.
IV. Artificial illumination : candles, oils and lamps, petroleum, gas and its products, electric light.
V. Limes, mortars, and cements.
VI. Building stones : decay and preservation.
VII. Timber and its preservation : pigments, paints, essential oils, varnishes.
VIII. Glass and ceramics.
IX. Explosives : gunpowder, guncotton, nitroglycerine, etc.

IN THE FOURTH YEAR.

(For students in the course of Analytical and Applied Chemistry, and of Metallurgy.)

I. Chemical manufactures : acids, alkalies, and salts.

(1.) Sulphur, sulphurous acid, hyposulphites, sulphuric acid, bisulphide of carbon, etc.

(2.) Common salt, soda ash, hydrochloric acid, chlorine, binoxide of manganese, bleaching powder, chlorates, chlorimetry, etc.

(3.) Carbonate of potash, caustic potash, alkalimetry, acidimetry, etc.

(4.) Nitric acid and nitrates.

(5.) Iodine, bromine, etc.

(6.) Sodium, aluminium, magnesium.

(7.) Phosphorus, matches, etc.
(8.) Ammonia salts.
(9.) Cyanides.
(10.) Alum, copperas, blue vitriol, salts of magnesia, baryta, strontia, etc.
(11.) Borates, staunates, tungstates, chromates, etc.
(12.) Mercury salts, silver salts, photography.
(13.) Electro-metallurgy.
(14.) Oils, fats, soaps, glycerine.

II. Food and drink : milk, cereals, starch, bread, meat, tea, coffee, sugar, fermentation, wine, beer, spirits, vinegar, preservation of food, tobacco, etc.

III. Clothing : textile fabrics, bleaching, dyeing, calico printing, paper, tanning, glue, India-rubber, gutta percha, etc.

IV. Fertilizers : guano, superphosphates, poudrettes, etc.

GEOLOGY AND PALÆONTOLOGY.

The course of instruction in this department is as follows :

SECOND YEAR.

Botany and Zoology, as an introduction to Palæontology —lectures throughout the year.

THIRD YEAR.

Lithology : Minerals which form rocks and rock masses of the different classes—lectures and practical exercises.

Geology : Cosmical, physiographic, and historical—lectures and conferences throughout the year.

FOURTH YEAR.

Economic Geology : Theory of mineral veins ; ores ; deposits and distribution of iron, copper, lead, gold, silver, mercury, and other metals ; graphite, coal, lignite, peat, asphalt, petroleum, salt, clay, limestone, cements, building and ornamental stones, etc.

MINERALOGY AND METALLURGY.

I. MINERALOGY.—The studies in mineralogy continue through two years. During the first year the students are instructed in the use of the blowpipe, in crystallography, and in theoretical mineralogy.

The instruction in blowpipe is entirely practical, and lasts through the first half of the year. It consists in instruction how to use the different flames, and in teaching the students how to examine mixtures, alloys, and natural compounds, so that they are able to determine with ease the constituents of a mixture containing a large number of simple substances. In order to do this, substances whose composition they know are given to them, upon which they are required to perform all the characteristic reactions which take place in the different flames with different fluxes. After they are sufficiently familiar with the behavior of substances the composition of which they know, they are given substances, the composition of which they do not know, to determine.

The collection of blowpipe substances, consists of four hundred alloys, mixtures, and minerals. Students are taught to examine qualitatively all the different commercial alloys and a large number of the natural combinations which exist in minerals. The blowpipe laboratory is a large well-ventilated room to which the students have access at all hours of the day, where each student has a drawer with a lock assigned to him, which he retains until the close of the term.

At the commencement of the second term the lectures on crystallography commence. They embrace the entire subject of crystallography, including the descriptions of both normal and distorted forms, for the study of which the students have access to a collection of over 300 models in wood, embracing all the theoretical forms. Besides this collection they have the use of the collection of 150 models in glass, and have access to the collection of minerals, most of the species of which are illustrated by models in wood,

showing the perfect and distorted crystallographic forms.

Conferences are held during the term, in which the students are required to determine models of the theoretical forms as well as those found in minerals. They are also taught theoretical mineralogy, including the optical and physical properties of minerals, which lectures are illustrated by very complete set of apparatus presented by F. A. Schermerhorn, and a cabinet containing a large number of sections of minerals for lantern and instrumental use. For the study of sections the students are taught the use of Groth's and Soleil's Polariscopes, and of Goniometers

At the commencement of the third year the students begin the study of practical mineralogy. They are required to determine minerals by the eye, or by asking questions with regard to those characteristics which cannot be determined without experiment. They are required to give the name, the composition, the crystalline form, and the prominent blowpipe chemical and physical characteristics of the mineral they determine. To facilitate this work they have unrestricted access to a collection of about 3,000 carefully labelled specimens, on which they are allowed to make any experiments. They have besides constant access to the cabinet of minerals, which contains about 30,000 specimens, arranged in table cases, to show the different characteristics of minerals, and about 3,000 specimens arranged in wall cases, to show their association. The crystals of minerals are arranged upon pedestals in such a way that they can be readily seen and examined by the students.

At the commencement of the second term of the third year they are required to determine the minerals without asking questions by making the usual chemical and blowpipe tests on specimens given to them for the purpose.

Most of the instruments in this department were presented to the School by D. Willis James, C. R. Agnew, and the late Gouverneur Kemble. The collection of minerals was founded by a valuable collection presented as the first

donation to the School, before it was opened in 1864, by the late George T. Strong of this city. It was shortly afterwards supplemented by another collection presented by the late Gouverneur Kemble, containing many autographs and specimens from the cabinet of Hauy. As these collections were both very rich in duplicates, very many valuable additions have been made to the cabinet by exchange. Collections were also made in Europe during several years by the Professor in charge, having the necessities of the collection of the school in view, and were presented to the school through the generosity of Morris K. Jessup, Wm. E. Dodge, Jr., D. S. Egleston, C. Lanier, and J. Crearer, of this city ; and the late John H. Caswell, Wm. H. Aspinwall, and R. P. Parrot.

II. METALLURGY.—The lectures in metallurgy continue through two years, and discuss in detail the methods in use in the best establishments in this country and in Europe for working ores. They embrace, in general metallurgy, the subjects of combustion, fire-clays, furnaces, natural fuels—wood, peat, lignite, bituminous and anthracite coals —artificial fuels, charcoal, peat charcoal, and combustible gases manufactured in generators, chimneys, the different kinds of blast engines, regulators, hot-blast ovens, and tuyeres.

The metallurgy of iron consists in discussion of the general properties of iron and its ores ; theory of the blast furnace process—the causes of variation in the charge produced in the furnace by the blast, by the fuels, by the variations in the charge, and by the form of the furnace : the effects of moisture ; the methods of ascertaining the cost; the calculations of the heat developed and lost in the furnace ; moulding; melting the iron in crucibles, in cupolas, in reverberatory furnaces ; methods of making the moulds ; precautions required in casting ; and the manufacture of malleable cast iron. In the manufacture of wrought from cast iron, the German process and its modifications are discussed; the English processes, including fining ; the dry and boiling process in puddling ; stationary and rotary

furnaces; shears; hammers; squeezers; saws; rolls; reheating in ordinary and regenerator furnaces; two and three high trains; method of calculating cost of wrought iron. In the manufacture of iron from the ore, the Catalan processes and its derivatives are discussed ; in the metallurgy of steel, low furnace processes, puddled steel, cement steel, Bessemer steel, Siemens-Martin's steel, crucible steel, the utilization of scrap iron, manufacture of sheet iron, nails, wire, and rails.

The lectures on the metals include the treatment of native copper; the treatment of pure sulphurous ores by the Swedish, German, and mixed methods in Europe and the United States; the treatment of rich pure ores; the treatment of impure ores in the Hartz mountains and in the United States; the treatment of very poor ores by lixiviation; the treatment of rich and pure ores by the English methods in the reverberatory furnace in the United States and Europe, and the treatment of impure ores in the same furnace; method of making calculations for works treating a definite number of tons; mixed method; treatment in Europe and in the United States; treatment of oxides of copper, wet methods; treatment of ores of lead, roasting and reaction in France, England, and the United States; method of roasting and reduction; method by precipitation in France, Germany, and the West; mixed method in France, Germany, and the West; refining of lead, extraction of silver by the Pattinson method and by zinc; cupellation; condensation of volatile products; treatment of silver ores in furnaces, in Germany and in the United States; separating of silver by amalgamation, Saxon method, Mexican method, pan amalgamation, treatment in the wet way; Augustin's methods, Ziervogel's methods, Von Patera's method; refining silver; treatment of gold ores, washing, sluicing, hydraulic mining, Plattner's process, parting gold and silver; treatment of tin, in shaft furnaces and in reverberatory furnaces; treatment of ores of zinc, Silesian method, Belgian method, English method, wet method; treatment of ores of mercury, method by precipi-

tation, by roasting, in Europe and in California, by the wet way; treatment of ores of antimony; treatment of nickel and cobalt; treatment of ores of bismuth.

It is designed to make these lectures as practical as possible, and for this purpose the economic details of cost are given whenever they can be obtained from authentic sources. Special details are given of the ores of this country which are difficult to treat, to the solution of practical problems which may occur, and to changes which different economic relations are liable to cause in the treatment of the same ore in different localities.

Nearly a thousand lecture diagrams and the same number of photographic illustrations for use in the lantern have been prepared to illustrate the furnaces, machines, and appliances used in the different metallurgical works, as well as to illustrate the construction of furnaces, etc.

The collection illustrating the department of metallurgy includes models of furnaces and a very large collection of drawings and tracings, in most cases copies from the working drawings of establishments in actual operation. This collection embraces several hundred tracings collected from the best types of works in this country and abroad, many of them being sufficiently detailed to be used as construction drawings.

The metallurgical collection, properly speaking, embraces about 3,000 specimens, illustrating every stage of all the prominent metallurgical processes. Many of these specimens have been analyzed and assayed. They are constantly open to the inspection of the students.

As an application of the lectures the students are required to work out a project, and to present working drawings and estimates for the erection of works to treat a given ore under stated conditions. The problems given are those which require solution in some parts of the United States.

ENGINEERING.

Engineering, in its widest sense, involves applications of the sciences of physics, mechanics, and chemistry to a great variety of problems met with in works and enterprises of a public and private nature or of an industrial character, in which the employment of materials, the building of structures, the use of machinery, the utilization of natural resources, or the protection or improvement of the ways of commerce, are essential and important elements and conditions. The educated engineer, whatever may be the branch of the profession to which he devotes himself, should, therefore, have a thorough foundation of knowledge in certain subjects of common application, for example, free hand and instrumental drawing, mathematics, physics, and mechanics, and the application of these sciences to the resistance of materials to machinery, to structures of iron and wood and masonry; the flow of streams in artificial channels required for waterworks, drainage, and for sanitary purposes; the theory of heat, as applicable to air and steam in their various uses, in ventilation, etc.

The courses in Mining Engineering and Civil Engineering are, therefore, identical in all that pertains to these subjects

It is essential, however, that in each of these branches of engineering the subjects technically appertaining to each should receive as great a share of the attention of the students, in the courses in Mining and Civil Engineering respectively, as possible in the short period devoted to collegiate instruction.

The mining engineer encounters in his practice questions which are rarely met with in civil engineering, for example, the results of experience in the searching for, winning, and exploitation of mineral deposits, special problems of ventilation, and drainage; while, on the other hand, he is seldom or never called upon to discuss questions which are common and important in the practice of civil

engineering, such as the supply of water to towns and cities, and other sanitary works, on a large scale, the erection of extensive public buildings, the improvement of harbors and rivers, works of irrigation, the building of extended bridges, etc.

The arrangement of the two courses in Engineering has been made under the above views of the subject, utilizing, as it does, in the best manner, the time of the instructors, and avoiding a repetition of the same instruction to different classes.

The collateral branches of study for the Engineering courses, Chemistry, Metallurgy, Geology, subjects quite as essential to mining and civil engineers as Physics and Mechanics, have also been assigned to these two courses, in accordance with the general requirements of the respective professions.

I. Drawing, Descriptive Geometry, etc.—The course in drawing embraces instrumental drawing, descriptive geometry, shades, shadows, and perspective, stone cutting, isometric drawing, topographical and geological drawing, drawings of engineering constructions and machinery.

The first year is devoted to the elements of instrumental drawing, the use of instruments, lettering, projections of objects, plans, sections and elevations, intersection of solids and of surfaces, and the development of surfaces.

During the vacation which follows, the execution of sketches from nature and from engineering and architectural constructions is required.

During the second year, the first session is occupied in the study of descriptive geometry, in grading and tinting as well as in topographical drawing.

The instruction in these subjects requires all the problems and illustrations to be carefully and neatly executed on the drawing board, and the principles of construction explained by the student in oral examinations.

During the second session, the subjects of shades and

shadows, perspective and isometrical drawing and stone cutting are taken up in the same manner. Practice is also given in drawing the simple elements of architecture, such as the plans of private and public buildings, showing the details of walls, floors, windows, and door casings, etc.

During the vacation which follows, definite architectural plans are required.

The drawing of the third year includes elements of machine construction, the drawing of maps from field work executed by the students themselves, parts of engines, geological drawings, etc.

During the vacation which follows, the necessary drawings for memoirs and theses are made.

The drawing of the fourth year is limited to working drawings of machines and engineering constructions, drawings illustrating the principles of mechanism, and the execution of plane table maps with contour lines, etc.

The whole course of drawing is progressive, and embraces nearly 100 sheets, each succeeding sheet being illustrative of a principle of construction or an advance towards more difficult methods or combinations; and it is designed to qualify students for the execution of all kinds of drawing, and the most difficult constructions.

II. Civil Engineering.—Instruction in civil engineering extends through the third and fourth years.

During the third year, the more simple elements of civil engineering and surveying are taught. In civil engineering the various subjects are considered in the following order: First, Materials—building-stones, limes, cements, mortar, concrete, brick, wood, metals; their properties and general qualities, mode of preparation, and their respective uses, and combinations in constructions, their strength and durability. Second, Masonry—construction of masonry, retaining walls, arches, etc. Third, Framing—structures of wood, carpentry. Fourth, Stone and Wooden Bridges—descriptions of various kinds of wood and iron trusses in use, suspension bridges, etc., general principles of roof con-

structions. Fifth, Common Road Construction—general principle of railway construction; construction of canals, general principles of rivers, slack water navigation, etc.

The instruction in surveying embraces a series of lectures on the principles of the subject and the use and description of instruments, and the following order of field work, viz.:

1. At the beginning of the third year, the students are divided into small squads of 3 to 6 each, each squad being provided with an instrument. The field work begins with instruction in general methods of ascertaining distances and dimensions without instruments, by pacing and by employing the height of the body, the length of the arm, etc., for obtaining rough measurements when instruments are not available.

2. The use of the compass for topographical surveys and for ascertaining areas; the use of the hand-level for contouring or for determining difference of levels, use of sextant, measurements with chain and tape, in making compass surveys, a map of each survey being made by each student.

3. Use of solar compass for U. S. land and mineral surveys.

4. Use of transit; measurement of angles, closed survey by traversing; calculation of coördinates; city surveying.

5. Use of surveyor's level; running line of level, trigonometrical leveling, by measurements of vertical angles.

Spring work—four or five weeks.

1. Use of plane table for a topographical survey of a portion of Central Park.

2 Magnetic survey with solar compass and dipping needle, with determination of curves of equal deviation and intensity.

Instruction in Practical Astronomy and Geodesy during the third year embraces:

1. A course of general lectures on Astronomy, fully illustrated by lantern views.

2. Lectures on Geodesy—general outlines of Geodesy—

description and illustration of the different kinds of triangulation, primary, secondary, and tertiary—description of the United States Coast Survey primary base apparatus—description of the United States Coast Survey secondary base apparatus—measurement of subsidiary base lines—reconnoissance surveys—stations and signals—observing tripods and scaffolds—station marks, underground and surface—observation of angles—instruments, direction and repeating—application of Legendre's Theorem to the solution of spheroidal triangles—records and computations—latitude, longitude, azimuth, and time observations and computations.

3. Practical use, in the observatory, of the transit instrument for time and zenith telescope for latitude, and, in the field, use of the sextant and reflecting circle for time, latitude, and longitude approximations.

During six weeks of the summer vacation, at the close of the third year, the students in Civil Engineering are required to make a geodetic survey of some region. In the summer of 1883 the survey of Otsego Lake, N. Y., is to be continued, at the request of the Director of the New York State Survey. The results of this survey are to be used by the State Board in constructing a map of that region.

During the fourth year a line of railroad is surveyed, locating the line on the ground, setting grade and slope stakes, levelling, and calculation of cuttings and embankments, drawings, and estimates. In addition, the course in railroad engineering embraces a series of practical lectures on permanent way, rolling stock, motive power, and administration of railroads, with instruction in the economics of location and transportation.

The course in civil engineering in the fourth year embraces the principles of mechanics applied to engineering constructions and to machinery, the strength of materials, the theory of retaining walls and arches, and the methods of determining the dimensions of the parts of iron roof and bridge trusses, by means of the stresses to which they are subjected, the theory of such structures and the de-

tails of practical construction; the principles of hydraulics applied to the improvements of rivers, the water supply of towns, reservoirs, dams, etc., and the general principles of sanitary engineering, drainage, sewers, house drainage and ventilation.

The students in the civil engineering course are also instructed in the principles of mechanism, beginning with the general theory of motion; the principles of transmission of motion, the various modes of mechanical connection, the calculation of relative velocities of moving pieces of machinery, valve gearing, and the mechanism, movements, and construction of machinery in practice; the dynamics of machinery or the determination of the relations between the forces which act upon machines, and the general application of mechanics to machines; the study of prime movers, including steam-engines, hot-air engines, and water wheels; the theory and construction of steam boilers, and the general principles of heat, as applied to air and vapors.

Instructions in Geodesy continued, by lectures and use of instruments—spirit levelling—trigonometric levelling—magnetic determinations—figure of the earth.

III. Mining Engineering.—The course in mining engineering is the same as that in civil engineering, in drawing and surveying, except that the students of mining will have additional instruction in underground surveying and geological reconnoissance. The courses in mining and civil engineering are also identical during the third year in all that relates to materials and general principles of engineering constructions, excepting that the course in mining engineering is intended to be more extended in the principles of mechanism and construction of machinery, and less extended in the detailed principles of roof and bridge construction, hydraulics as applied to river improvements, sanitary engineering, water supply of towns, etc.

During the third and fourth years, the course in mining engineering embraces lectures on practical mining, or miners' work, including excavation of clays, peat, bog iron

ore, and other easily worked materials; quarrying for extraction of large blocks of stone, marble, etc.; blasting, drilling tools, hand boring, use of explosives; well-boring, by hand for exploration, and machine-boring, sinking of shafts and slopes, timbering and driving of adits and levels, in the use of picks and gads in the mining of coal, salt, fire-clay, and other soft rocks, coal-cutting machines, mining of ores and hard rocks; handling of excavated mineral in working places; underground transportation, tramming by man or animal power, mechanical haulage with chains or wire-rope, and by underground locomotives; accidents to men, their cause and prevention; organization and administration; mine book-keeping; accounts with men, time books, pay roll, analysis and dissection of mine accounts and making out of cost sheets.

The instruction in mining engineering during the fourth year is the same as for the civil engineers in all that relates to the general dynamics of machinery, and to the application of the principles of mechanics to engineering constructions. It is more extended in the application of machinery to mining purposes, especially in connection with the use of compressed air, pumping and ventilating machinery, and hoisting machinery.

It embraces also the study of mineral deposits, classification and description of veins, beds, and masses, and their geological characteristics, interruptions and intersections, methods of prospecting, of reaching deposits, of prosecuting the underground workings; and methods of making and supporting excavations made for special purposes, junctions of levels, chambers for machines, and of making and supporting excavations in watery strata; proper provisions for pumping and ventilation; general principles to be observed in laying out, opening and working mines, and methods applicable to special deposits, such as narrow and wide veins or lodes, thick and thin seams of coal; hydraulic mining, etc.; also instruction in the proper administration of mining works, exterior transportation, mine regulations, etc.

A course of lectures on ore dressing includes the genera principles of ore dressing, preliminary hand dressing, and sorting and preliminary cleansing and sizing; crushing by hand and with machinery; cleansing in ditches and troughs, in sieves, trommels, and by special machines; sizing, bar gratings, and other stationary screens, riddles, revolving screens; concentration of coarse and fine material by jigs, buddles, tables, etc.; illustrations from American and foreign practice; mechanical preparation of coal and other minerals, and the concentration and purification of copper, lead, iron, and other ores.

A course of lectures, fifty or sixty in number, is delivered during the third and fourth years to students in Civil and Mining Engineering on the properties of the metals used in engineering constructions. These lectures are devoted principally to iron and steel, but include also other metals and alloys. They treat of the mechanical processes by which these metals are transformed into the shapes required by the engineer from the crude state in which they are found, after reduction by metallurgical processes from their ores. The physical properties of such fabricated materials under the various uses and conditions to which they are subjected in engineering constructions are also treated. The lectures are intended to cover as far as possible a field of knowledge which of late years has grown into great importance and prominence as an essential branch of an engineer's acquirements, and which connects the science of metallurgy with the art and practice of engineering. This field embraces not only the arts of fabrication of merchant forms, but also the physical and mechanical properties of the metals in such forms: such as coefficients of strength, limits of elasticity, ductility, adaptability for particular uses and different conditions, etc., which vary greatly with the processes through which the metals have passed, and yet from their nature require to be treated in connection with engineering problems. Instruction is also given in inspection and testing of these materials delivered under contract, embrac-

ing the usual practical physical tests, and the relations so far as known between chemical analysis and physical characteristics.

In view of the paramount importance of iron and steel to the engineer of to-day considerable time is devoted to these metals. The inspection and grading of pig-iron, and the suitability of different grades for various kinds of castings; cupola furnaces and cupola mixtures and their effects upon product; special dangers inherent in castings of certain shapes; principles in design of castings; shrinkage strains and lines of weakness in castings; defects due to cores and to moulds; resistance of cast iron to corrosion and protection from it; inspection of castings—these are included in a first series.

Chilled castings—their characteristics, uses, production, and dangers: and malleable castings are similarly treated, including their action under heat and under tools, and the brazing of castings.

Under the head of wrought iron are discussed: piling, heating and rolling of muck bar; effects of heating and rolling on merchant bar; forge uses and tests of bar; requirements of metal for plate, for tube, for wire, and for special forged shapes, such as bolts, etc. Heating, piling, and rolling for shapes or structural iron; points of defect, characteristics of different shapes, adaptability for different uses; possible sections and areas; combination of sections; protection from corrosion; inspection of structural iron. Fabrication of ship and boiler plate: methods and processes, properties, defects, requirements, and inspection. Fabrication of tube and pipe, lap and butt-welded; continuous and universal mills, bending, welding, and straightening rolls, swaging, testing, and tool work. Fittings, forms and uses.

Under the head of steel are treated: properties of crucible steel resulting from its manufacture, such as uniformity of temper, adaptability for tools and cutters. Bessemer and Siemens-Martin steels: properties of ingot metals, mill and furnace treatment for shapes, springs, tires, bars,

and plate; characteristics of ingot plate, effects of alloying impurities.

Steel castings: their production, characteristics, and defects.

Iron and steel forgings: drop forging, die forging, machine forgings large and small, heating and handling, excellences and sources of defect. Burnt iron and steel.

Incidentally to these topics is discussed the machinery for handling the materials in process of manufacture, so far as they are essential to the primary object in view.

After iron and steel, follow lectures upon a similar plan, discussing brass cast rolled and drawn, copper sheets and tubes, lead pipe and sheets, zinc and tin sheet and tube, and galvanized and tinned plate, certain alloys for special needs against friction, corrosion, etc, and the brazing and soldering processes for the various metals receive attention at the close.

ARCHITECTURE.

During the second year the time which is given in the other courses to laboratory work is in this course given to architectural drawing. This is so laid out as to include exercises in the ordinary processes of draughtsmanship, the making of plans, elevations, sections, and details, both on a large and on a small scale; using pencils and pens, brushes and colors, with auxiliary exercises in tracing and sketching. The examples are so chosen as to make the student familiar with the commonplaces of architectural form, and are accompanied by lectures upon the Elements of Architecture, in which the forms and proportions of the Greek and Roman Orders, of doors and windows, arches, staircases and balustrades, domes and vaults, roofs and spires, are set forth, and the best ways of drawing them explained. At the same time a series of illustrated lectures is given upon Egyptian, Assyrian, Greek, and Roman Architectural History.

During this year the students of architecture complete their elementary studies in Mathematics and Chemistry,

French and German, following at the same time the work in Descriptive Geometry, Stone Cutting, and Shades, Shadows, and Perspective, given in the Department of Engineering, and a portion of the work in Geology.

In the third and fourth years the study of scientific construction is pursued in connection with the classes of Engineering, most of the time, however, being given to strictly professional work. This is for the most part pursued by the two classes in common, one class taking up in their fourth year what the next class takes in the third, and *vice versa*, the whole thus forming a single two years' course. These studies are arranged under four heads:

I. Under the head of History, the architecture of the Middle Ages is taken up in one year, and that of the Renaissance, and its more modern derivatives, in the next. On completing the study of ancient architecture, then, in the second year, one class goes on directly to that of the Middle Ages in the third year, and to that of the Renaissance in the fourth. The next class passes at once from ancient classical architecture to modern, finishing with the Mediæval styles.

II. Under the general head of Ornament, etc., is comprised the study of the decorative details of the different architectural styles, and of the contemporary forms in other branches of art, especially the decorative arts employed in building. The materials and processes employed in these arts, and the theory of æsthetics, in form and color, come under this head.

III. Under the head of Architectural Practice comes the study of specifications and working drawings, so far as they can profitably be studied in such a school, and of the materials and processes employed in building operations. The buildings erecting in the neighborhood will here serve as examples, and a special architectural laboratory will afford opportunity for the study of oils and paints, cements, mortars, etc., and of testing their quality. Ex-

periments upon the strength of materials will be made at the same time by the classes in Civil Engineering.

IV. Under the head of Drawing and Design is comprised the practice of original composition in the working out of problems in design, from given data, as well as further exercises in draughtsmanship, both free-hand and with the pencil, pen, or brush, illustrating the study of the special topics enumerated above. The laboratory will be provided with facilities for modelling in clay or wax, and for working in plaster.

The students of the fourth year will give a certain portion of time to exercises of a critical and literary character, designed to practise them both in reading and in writing.

The buildings now in process of erection will afford ample accommodation for this work, and for the necessary collections of drawings, photographs, casts, and books.

MEMOIRS, PROJECTS, AND DISSERTATIONS.

The following memoirs, projects, and dissertations required from students of the several classes of the year 1881–82, are given simply to illustrate the kind of work required by By-laws 22 and 24, pages 14 and 15.

Students of the Second Class in all the courses were required to hand to the Instructor in Drawing, on or before October 3, 1881, six free-hand sketches, as follows :

No. 1. Hoisting Machine.
No. 2. Stone Doorway.
No. 3. Bridge.
No. 4. Staircase.
No. 5. Steam Pump.
No. 6. Railroad Car.

These sketches must be drawn from the objects themselves, on sheets 15x22 inches, and location, date, and signature must be given on each.

COURSE IN MINING ENGINEERING.

Students of the Third Class were required to hand to the Professor of Engineering, on or before October 3, 1881:

For those not attending the Summer School of Mechanical Engineering, six drawings, 15x22 inches, as follows:

No. 1. Orthographic View. Plan and Elevation of a Building, Dimensions, etc., assigned in class.

No. 2. Details—Doors, Windows, Stairs, etc.

No. 3. Tracing of No. 2.

No. 4. Enlarged Plan and Elevation of principal entrance, with details.

No. 5. Perspective View of Exterior.

No. 6. Isometric View of Exterior.

For those attending the Summer School of Mechanical Engineering, descriptive and illustrated memoirs upon shop practice.

Students of the Fourth Class were required to hand to the Professor of Engineering, on or before October 3, 1881:

A MEMOIR upon some topic assigned to each member of the class in connection with the Summer School in Practical Mining.

And on or before January 13, 1882, to hand in to the Professor of Metallurgy:

A METALLURGICAL PROJECT on a subject assigned by the Professor of Metallurgy.

COURSE IN CIVIL ENGINEERING.

Students of the Third Class were required to hand to the Professor of Engineering, on or before October 3, 1881;

For those not attending the Summer School of Mechanical Engineering, six drawings, 15x22 inches, as follows:

No. 1. Orthographic View. Plan and Elevation of a Building, Dimensions, etc., assigned in class.

No. 2. Details—Doors, Windows, Stairs, etc.

No. 3. Tracing of No. 2.

No. 4. Enlarged Plan and Elevation of principal entrance, with details.

No. 5. Perspective View of Exterior.

No. 6. Isometric View of Exterior.

For those attending the Summer School of Mechanical Engineering, descriptive and illustrated memoirs upon shop practice.

Students of the Fourth Class were required to hand to the Professor of Engineering, on or before October 3, 1881, descriptive memoirs upon engineering topics assigned to the member individually, embracing: Reclamation of Tide Lands at Green River Harbor, Mass.; Methods of Laying Out and Constructing Roadways on Pennsylvania Railroad; Improvements of Charleston Harbor, S. C., and Cape Fear River, N. C.; Construction of new Railroad Bridge across the Harlem River at 155th Street.

COURSE IN METALLURGY.

Students of the Third Class were required to hand to the Professor of Metallurgy, on or before October 3, 1881:

A MEMOIR on one of the following subjects:

(1.) The occurrence, preparation, and properties of Ozone. (2.) The comparative certainty and delicacy of the different qualitative tests for arsenic. (3.) The occurrence and detection of Titanium. (4.) The qualitative detection and separation of Nickel and Cobalt.

Students of the Fourth Class were required to hand to the Professor of Metallurgy, on or before October 3, 1881:

A MEMOIR on one of the following subjects:

(1.) Regenerative Furnaces. (2.) Blair's Direct Process. (3.) The Siemens-Martin Process.

And on or before January 13, 1882:

A METALLURGICAL PROJECT on a subject assigned by the Professor of Metallurgy.

COURSE IN GEOLOGY AND PALÆONTOLOGY.

Students of the Third Class were required to hand to the Professor of Geology, on or before October 3, 1881:

A MEMOIR on one of the following subjects:

(1.) Notes on the Flora or Fauna of any geographical district visited. (2.) Observations on the structure, distri-

bution, and habits of any of our fresh-water Fishes. (3.) Catalogues and collections of Mollusks inhabiting any lakes, rivers, or districts. (4.) Notes on the economy of observed Insects. (5.) Notes on the various observed methods by which the Seeds of Plants are distributed.

Students of the Fourth Class were required to hand to the Professor of Geology, on or before October 3, 1881:

A MEMOIR on one of the following subjects:

(1.) Report on the Geology of any district visited. Embracing: *a.* Topographical features and their causes. *b.* Surface geology. *c.* Sections of strata, with lithological character, thickness, dip, strike, and fossils of each bed. Sketches of rock outcrops. *d.* Suites of specimens of rocks and fossils, rocks $3\times4\times1$ inches.

(2.) Report on any special formation which may be examined. Embracing: *a.* The geographical area of its outcrops. *b.* Its mineral character, and origin of the material composing it. *c.* Sets and collections of its fossils. *d.* Reading of the history of its deposition.

(3.) Report on any examined deposits of ore or other useful minerals: as, *a.* The Magnetic Iron Ores of New York and New Jersey, phenomena and history. *b.* The Limonite Ores of the Alleghany Belt, character of deposits and age. *c.* The Zinc Ores of Franklin and Friedensville. *d.* The Chromic Iron of the Alleghany Belt, where and how it occurs.

And on or before the 15th of April, 1882:

A DISSERTATION on one of the following subjects:

(1.) The Mesozoic Sandstones of New Jersey and the Connecticut Valley; their geological phenomena, history, and relations to the associated trap rocks.

(2.) The Limonite Ores of the Alleghany belt; their phenomena, age, and origin, *i. e.*, where and how they occur, when and how they are deposited.

(3.) Eozoon Canadense; is it organic?

COURSE IN ANALYTICAL AND APPLIED CHEMISTRY.

Students of the Third Class were required to hand to the Professor of Chemistry, on or before November 3, 1881:

A MEMOIR on one of the following subjects:

(1.) Water Gas. (2.) Petroleum. (3.) Photo-Mechanical Processes. (4.) Gun Cotton.

The Memoir must include a general account of the group; constitution, formation, physical and chemical properties, and decompositions; together with a complete classified list of all the members of the group, with the names of the discoverers, date of discoveries, and references to original publications.

The students of the Fourth Class were required to hand in to the Professor of Chemistry, on or before November 3, 1881:

A MEMOIR on one of the following subjects:

(1.) Artificial Stone. (2.) Artificial Indigo. (3.) Quinine and its allies. (4.) Resins and Varnishes.

The Memoir must contain full references to authorities throughout the text, a table of contents, and an index.

And on or before April 14, 1882:

A CHEMICAL DISSERTATION on a subject which they may select, subject to the approval of the Professor of Chemistry.

NOTE.—All Memoirs and Dissertations must be written on paper 8×10 inches, with a margin of one inch, and be illustrated by drawings made to scale, on paper 24×36 inches in size, and accompanied, when possible, by specimens.

VACATION WORK.

During the vacations at the close of the first, second, and third years, students are required to prepare memoirs on subjects assigned to them by the Faculty. Specimens illustrative of the kind of work required in the memoirs have just been given.

During the vacation a class in practical mining, composed of students in the course in Mining Engineering who have completed the third year, is required to visit a mine for practical mine work. The class is under the immediate superintendence of the Adjunct Professor in Surveying and Practical Mining, and is occupied in this way from four to six weeks.

During the vacation, also, a volunteer class in practical mechanical engineering is formed from among the students of either of the Engineering courses who have completed their second year, for the purpose of visiting foundries and machine shops in the city, and engaging in practical work and study. This class is under the immediate supervision of the Adjunct Professor of Mechanical Engineering, and is occupied in this way four or five weeks of the months of June and July.

During the vacation a class in practical geodesy, composed of students in the course of Civil Engineering who have completed the third year, is required to make a geodetic survey of some region. This includes measuring a base line with a United States Coast Survey secondary base apparatus—secondary and tertiary triangulation with eight inch theodolite—trigonometric levelling with eight inch theodolite, with vertical circle :

Determination of time, latitude, and azimuth, using portable transit, zenith telescope, and theodolite :

Approximate determinations of time, latitude, and longitude, with sextant and reflecting circle.

The class is under the immediate supervision of the

Director of the Observatory and Instructor in Geodesy. The work for the summer of 1883 will be the continuation of the survey, for the New York State Survey, of Otsego Lake.

TEXT BOOKS.

(The text books required by the first and second classes are named in connection with the subjects in the Synopsis of Studies.)

Books preceded by an asterisk (*) are optional—the others are indispensable.

THIRD CLASS.

Peck's Mechanics (new edition).
Murray's Land Surveying.
Newcomb's and Holden's Astronomy.
* Publications of the U. S. Coast and Geodetic Survey, relating to the fundamental geodetic operations.
* Rankine's Machinery and Mill Work.
Mahan's or Wheeler's Civil Engineering.
Gillmore's Roads and Pavements.
Stoney's Theory of Strains.
Searle's Henck's Field-book for Engineers.
* Davis's Formulæ for Railroad Earthwork.
Ritter's Iron Bridges and Roofs.
* Callon's Lectures on Mining.
Johnson's Fresenius's Quantitative Analysis.
Dana's Manual of Geology.
Nicholson's Palæontology.
Wagner's Chemical Technology.
* Kerl's Metallurgy.
Plattner's Blowpipe Analysis.
Egleston's Lectures on Mineralogy.
Egleston's Tables for Determining Minerals.
Egleston's Metallurgical Tables.
Egleston's Tables of Weights, Measures, Coins, etc.
Von Cotta and Lawrence's Rocks.
Cairn's Quantitative Analysis.

FOURTH CLASS.

Burat's Géologie Appliqué.
* D'Orbigny's Palæontologie Elémentaire.
Ricketts' Manual of Practical Assaying.
* Whitney's Metallic Wealth of the United States.
* Kerl's Probirkunst.
Egleston's Metallurgical Tables.
* Cotta's Treatise on Ore Deposits, by Prime.
Page's Economic Geology.
Weisbach's Mechanics of Engineering.
Callon's Lectures on Mining.
* Burat's Exploitation des Mines.
* Rigg on the Steam Engine.
Goodeve on the Steam Engine.
* Welsh's Designing Valve Gearing.
Rankine's Prime Movers.
Rankine's Civil Engineering.
Rankine's Machinery and Mill Work.
* Lottner's Bergbaukunst.
Stevenson on Harbors.
Stevenson on Canals and Rivers.
* Vose's Railroad Engineering.
* Clarke's Geodesy.
Henck's Field-book for Engineers.
Ritter's Iron Bridges and Roofs.
Greene's Graphical Statics.
* Publications of the U. S. Coast and Geodetic Survey, relating to the fundamental geodetic operations.
* Gaetschman's Aufbereitung.
Fanning's Water Supply Engineering.
Latham's Sanitary Engineering.
* Röntgen's Thermodynamics, Du Bois's Translation.
* Planât on Warming and Ventilation.
* Joly, Warming and Ventilation.
* Colyer's Hydraulic Lifting and Press Machinery.
* Rittinger's Die Aufbereitungkunde.

Allen's Introduction to the Practice of Commercial Organic Analyses.

Berthelot's Leçons sur les Methodes Générales de Synthèse en Chimie Organique.

Berthelot and Jungfleisch's Traité Elémentaire de Chimie Organique.

Roscoe and Schorlemmer's Treatise on Chemistry. (Organic Chemistry.)

Strecker's Short Text Book of Organic Chemistry by Wislicenus.

LIBRARY.

The Library of the School of Mines, established when the school was founded, was especially designed to assist the students in the course of studies pursued in the various departments. Having at the time no fund for the purpose, a portion of the college library appropriation was devoted to the purchase of a few books which partially supplied the existing needs. To these were subsequently added about a thousand volumes removed from the library of the School of Arts to another department, and a further increase was soon after made by the addition of books obtained in exchange for duplicate reports of Natural History, Surveys of States and Territories, presented by various authorities. Since then frequent donations, and a gradually increasing annual appropriation, have raised the number of volumes to about eighty-five hundred.

The number of volumes upon its shelves, however, affords by no means a just measure of the value of the library, which consists rather in the judicious selection of standard and recent works in the various departments of science which it embraces, and in their adaptation to the specific wants of the school.

The catalogue contains the titles of about three thousand monographs, rather more than one half of which are in the English language, and the remainder in German and French. But the most important feature of the library,

and that which places it in advance of others much larger, is its valuable collection of periodical publications, which now make up about half the number of volumes collected. The present subscription list comprises a hundred and fifty serials devoted to science and the arts, published at the various literary and scientific centres of the world. The early numbers of some of the most important of these have been procured, and form complete series not to be found elsewhere in New York, or, indeed, in the country. Valuable maps and volumes of plates have also been added to the library by purchase and by generous donations to which the School of Mines is frequently indebted for important acquisitions. The appropriations made by the Trustees for the increase of the library have gradually increased from sums of less than five hundred dollars to two thousand dollars per annum. The books are arranged upon the shelves in alphabetical order, and in sections bearing labels which indicate the subject to which each is devoted. A catalogue was published in 1875, giving, first, the systematic works and periodical publications, arranged alphabetically, without reference to subjects; and secondly, the same titles repeated and classified according to a logical method. This is supplemented by catalogues printed each session, containing the list of books recently added.

CABINETS AND COLLECTIONS.

Collections of specimens and models, illustrating all the subjects taught in the school, are accessible to the students, including:

Crystal Models.
Natural Crystals, Pseudomorphs.
Ores and Metallurgical Products.
Models of Furnaces.
Collection illustrating Applied Chemistry.
Fossils.
Economic Minerals.
Rocks.
Oliver's Models of Descriptive Geometry.

Models of Mechanical Movements.
Models of Mining Tools.
Models of Mining Machines.
Casts, Antique Statuary, Animals, etc.

Crystal Models.—The lectures on crystallography are illustrated by a collection of 150 models in glass, which show the axes of the crystals and the relation of the derived to the primitive form. This suit is completed by 400 models in wood, showing most of the actual and theoretical forms.

Minerals. — The cabinet of minerals comprises about 30,000 specimens, arranged in cases. It includes a large suit of pseudomorphs, and a collection illustrating crystallography by natural crystals, showing both their normal and distorted forms. The minerals are accompanied by a large collection of models in wood, showing the crystalline form of each. Arranged in wall cases are large specimens, showing the association of the minerals.

Ores and Metallurgical Products.—A very complete collection of metallurgical products, illustrating the different stages of the type process in use in the extraction of each metal in this country and in Europe, is accessible to the students. This collection is constantly increasing. Most of the specimens have been analyzed and assayed.

Models of Furnaces. — An extensive collection of models of furnaces has been imported. A very large number of working drawings of furnaces and machines used in the different processes is always accessible to the students.

Applied Chemistry is illustrated by several thousand specimens of materials and products, arranged in a cabinet of industrial chemistry, for exhibition at the lectures and for inspection by the students.

The Geological Collection consists of over 80,000 specimens (to which additions are constantly made), forming the following groups :

1st. A systematic series of the rocks and fossils characteristic of each geological epoch, numbering over 50,000 specimens.

2d. A collection of ores, coals, oils, clays, building materials, and other useful minerals, illustrative of the course of lectures on Economic Geology, and believed to give the fullest representation of our mineral resources of any collection yet made.

3d. A collection of 5,000 specimens of rocks, and the minerals which form rocks, to illustrate the lectures on Lithology.

4th. A Palæontological series, which includes collections of recent and fossil vertebrates, articulates, mollusks, radiates, and plants. In this series is to be found the largest collection of fossil plants in the country, including many remarkably large and fine specimens, and over 200 species, of which representatives are not known to exist elsewhere. Also, the most extensive series of fossil fishes in America, including, among many new and remarkable forms, the only specimens known of the gigantic *Dinichthys;* a suit of Ward's casts of extinct saurians and mammals; a fine skeleton of the great Irish elk, etc., etc.

Drawing Models.—There are, for the use of students, a large collection of flat models and of plaster casts; the Olivier models, forming all mathematical surfaces by silk threads, and admitting of a variety of transformations; also other models, illustrating general and special problems of descriptive geometry, shades and shadows, and stone cutting; photographs of plaster casts and of parts of machines for use in free hand drawing; drawings of machines and parts of machines for studying and copying; also, landscapes in crayon and in water color for instruction in sketching; models of mining machines and mining tools, stationary steam engines, single and double cylinders, sections of steam cylinders, water wheels, turbines; shaking tables, stamps, crushers, blowing machines, pumps, etc.

Civil Engineering is illustrated by a collection of models of beams, beam joints, roof and bridge trusses, masonry doorways, arches, walls. culverts, bridges, and canal locks; working models of overshot, breast, undershot, and different kinds of turbine water wheels; a machine, made by Fairbanks & Co., for testing the strength of materials; a five inch condensing steam engine, with a stroke of six inches; horizontal, vertical, and sectional steam engines and valves, etc.

There has recently been added to the department of Engineering for the use of students in Geodesy two four metre compound bars with Borda's scales, etc., for measuring base lines; one standard four-metre bar; one eight-inch theodolite with horizontal and vertical circles for measuring horizontal angles and double zenith distances.

Mining Engineering is illustrated by models of blowing engines, ventilators, mine shafts, tunnels, galleries, methods of walling, methods of tubbing shafts, methods of measuring shafts, shaft house, hoisting engine, safety cages, man-engines, ladders, shaking tables, washers, stamps, crushers, mining machines, lamps and tools, artesian well-borer, blasting apparatus, etc.

Additions to the various collections are constantly made.

ASTRONOMICAL OBSERVATORY.

The Astronomical Observatory contains a set of portable astronomical instruments; a forty-six inch transit, by Troughton & Simms; a combined transit and zenith instrument for time and latitude determinations; an equatorially mounted refractor of five inches aperture, to which is attached a spectroscope with the dispersive power of twelve flint glass prisms of fifty-five degrees, by Alvan Clark; also a diffraction spectroscope with grating, by L. M. Rutherfurd, Esq.

A set of comparison apparatus, with electrodes, Plücker's tubes, coil, etc., accompanies the spectroscope.

Instruction in practical astronomy is given in the observatory to students of the Third and Fourth Classes in the course of Civil Engineering.

DEGREES.

Those who complete the required course of studies will receive the degree of Engineer of Mines, Civil Engineer, or Bachelor of Philosophy.

Graduates of the school who pursue, at the school, for not less than one academic year, a course of study prescribed by the Faculty, pass a satisfactory examination thereon, and present an acceptable dissertation embodying the results of special study upon an approved subject, receive the degree of Doctor of Philosophy.

CALENDAR.

1883—June 8.—Examinations for Admission begin, Friday.
Sept. 25.—Examinations for Admission begin, Tuesday.
Oct. 1.—First Session begins, Monday.
Nov. 6.—Election Day, Holiday.
Nov. —Thanksgiving Day, Holiday.
Dec. 24.—Christmas Holidays begin, Monday.
1884—Jan. 7.—Lectures resumed, Monday.
Jan. 28.—Examinations begin, Monday.
Feb. 6.—First Session ends, Wednesday.
Feb. 7.—Second Session begins, Thursday.
Feb. 22.—Washington's Birthday, Holiday.
Feb. 27.—Ash Wednesday, Holiday.
April 11.—Good Friday, Holiday.
April 14.—Easter Monday, Holiday.
May 19.—Annual Examinations begin, Monday.
May 30.—Decoration Day, Holiday.
June 11.—Commencement, Wednesday.